ELECTRIC VEHICLE TECHNOLOGY AND COMMERCIALIZATION

HEARING

BEFORE THE

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

OF THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

SEPTEMBER 25, 1990

[No. 162]

Printed for the use of the
Committee on Science, Space, and Technology

U.S. GOVERNMENT PRINTING OFFICE

36-829 == WASHINGTON : 1990

For sale by the Superintendent of Documents, Congressional Sales Office
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ELECTRIC VEHICLE TECHNOLOGY AND COMMERCIALIZATION

TUESDAY, SEPTEMBER 25, 1990

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON TRANSPORTATION,
AVIATION, AND MATERIALS,
Washington, DC.

The subcommittee met, pursuant to call, at 1:50 p.m., in room 2318, Rayburn House Office Building, Hon. Robert G. Torricelli [chairman of the subcommittee] presiding.

Mr. TORRICELLI. Good afternoon and welcome.

Today, the Subcommittee on Transportation, Aviation, and Materials will turn to a subject that touches on one of the great ironies of our age. We find broad public support for spending approximately $1 billion per month in risking the lives of young Americans in service, all to protect a threat to Persian Gulf oil supplies. Yet, despite this apparent willingness to spend the great resources of our country, human and otherwise, for the last 10 years successive administrations have been unwilling to advocate even a small fraction of that amount to find real and lasting and safe alternatives.

We learned a decade ago that depending on an oil lifeline from an unstable region of the world was a certain formula for economic difficulty, yet it seems we are doomed to relearn that lesson. Our dependence on foreign oil has crept back to nearly the worst levels of the 1970's. In recent months, we have imported almost half of our total requirements. If this were not reason enough to be alarmed, we also have the increasing threat to our health caused by air pollution, which is largely caused by the consumption of petroleum.

This morning's news reported a sharp rise yesterday in the price of oil to over $38 per barrel, almost reaching historic levels, and that figure does not reflect the true cost which, in any estimation, must now include military operations and the indirect costs to our economy, making the real cost of petroleum at all time historic highs.

Today's hearing, scheduled some time ago and considerably before the invasion of Kuwait, will focus on the worst offender in our consumption of petroleum products, the transportation sector. It alone accounts for nearly two-thirds of all petroleum consumption in this country. We particularly want to look at the status and prospects of electric vehicles, a technology widely regarded as offer-

ing real hope for addressing the threat to both our personal and economic health caused by our tremendous thirst for oil.

The administration's record of support for electric vehicle technology during the 1980's will certainly be seen as nothing short of a tragedy, an enormous missed opportunity, if we are forced shortly into a shooting war in the Gulf, but in economic terms a tragedy in its own right. The latest budget request reversed a previous practice of recommending terminations, certainly a welcome sign, but it still falls far short of what was spent in the 1970's and, in fact, far short of what is needed.

Today, we plan to review both the current status of electric vehicle technology and to examine approaches to bring about widespread use. One such approach is embodied in H.R. 3852, the Electric Vehicle Technology Development and Demonstration Act of 1990, introduced by Mr. George Brown of California.

Mr. Brown, as most people know, has been a leader in advocating this technology for many years, principally as author of the original Electric Vehicle Act which created the present Department of Energy program. Since then, he has fought an uphill struggle to keep attention on the need for transportation energy conservation research. His latest legislative effort focuses on some of the obstacles to further progress towards EV commercialization, particularly the high price to consumers of initial models.

Before yielding to other Members as they arrive, I would conclude simply by raising this question: Where would we be today had we invested just one month's cost of the Persian Gulf operation in the further development of electric vehicle technology? How different the sacrifices, how different the costs to all Americans.

I would also like our audience to know today, and our witnesses, that on display in the Rayburn horseshoe is the G-Van, a development sponsored by the Electric Power Research Institute and supplied by Southern California Edison. It is, in many ways, a state of the art of the technology, and we welcome those of you who are present today to inspect it.

I have requests for opening statements which we will submit to the record from Mr. Campbell and Mr. Brown's, if he does not arrive shortly to deliver in person. If there is no objection, they will be entered into the record.

[The prepared opening statements of Messrs. Campbell and Lewis follow:]

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STATEMENT OF CONGRESSMAN TOM CAMPBELL

Hearing on H.R. 3852 in the
Subcommittee on Transportation, Aviation, and Materials
Committee on Science, Space, and Technology
September 25, 1990

Mr. Chairman, thank you for convening this hearing today on the legislation introduced by Congressman Brown. I am proud to be a cosponsor of this bill and am pleased to have the opportunity to discuss it with our distinguished witnesses.

Mr. Chairman, the need to reduce our dependence on fossil fuels did not begin with the current crisis in the Persian Gulf. We struggle to find ways to deal with air pollution, offshore oil spills, and the threat of global warming. Our trade deficit remains a persistent problem, threatening our economic security. All of this requires a move away from fossil fuels and toward the development of alternative energy sources.

Electric vehicles could significantly help. Contrary to popular perception, electric vehicles are not golf carts. General Motors, for example, has developed a model can go as fast as 100 miles/hour, and from 0 to 60 in eight seconds. The technology is there, but the cost per copy needs to come down before these vehicles can come into widespread use in this country. H.R. 3852, the Electric Vehicle Technology Development and Demonstration Act, can help this happen. The bill is designed to assure that, by providing federal cost-sharing during the early years of product introduction, the market will have the chance to become familiar with electric vehicles and ultimately adopt this technology.

For southern California, and other areas of the country that suffer similar problems with nonattainment of air quality standards, electric vehicles may prove to be the only answer to the problem of pollution originating from mobile sources. The country as a whole can also benefit from widespread use of electric vehicles, both from an environmental perspective and from the advantage of reduced dependence on imported oil.

Mr. Chairman, thank you again for holding this hearing. It is highly appropriate for our subcommittee to be considering innovative approaches to our nation's transportation problems.

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HON. TOM LEWIS (R-FL)

OPENING STATEMENT

HEARING ON ELECTRIC VEHICLE TECHNOLOGY

SEPTEMBER 25, 1990

THANK YOU, MR. CHAIRMAN.

THE DRAMA UNFOLDING IN THE MIDDLE EAST HAS HAD A LOT TO DO WITH AMERICA'S CONCERN WITH OUR PRECIOUS ENERGY SUPPLIES. TODAY, WE ARE LOOKING AT THE NEED TO FIND A SUBSTITUTE FOR GASOLINE TO PROPEL OUR CARS.

THE DEPARTMENT OF ENERGY IS STUDYING IF THE INTRODUCTION OF ENERGY STORAGE AUTOMOBILES WILL REDUCE PETROLEUM DEMAND. THE TIME OF INTEREST FOR THE STUDY EXTENDS TO THE YEAR 2000.

THE ELECTRIC VEHICLE CAN HAVE AN IMPORTANT ROLE TO PLAY IN OUR FUTURE PRIVATE TRANSPORTATION SYSTEMS. THIS ROLE WILL BE DETERMINED BY: TECHNICAL FACTORS, COST, INFRASTRUCTURE REQUIREMENTS, ENERGY-USE IMPACT, AND CONSUMER ACCEPTABILITY.

THE FUTURE FOR THE PRIVATE AUTOMOBILE IS CHANGING RAPIDLY. FUEL PRICES ARE SOARING. WHAT WAS NOT ACCEPTABLE IN THE PAST MAY BE IN THE FUTURE.

TO ACCELERATE THIS EFFORT, WE ARE EXAMINING LEGISLATION TO MANDATE THE USE OF ELECTRIC VEHICLES BY FEDERAL AGENCIES AND OTHERS. THIS WOULD REDUCE THE USE OF PETROLEUM SUPPLIES AND IS ENVIRONMENTALLY DESIRABLE.

THE QUESTION I HAVE IS WHEN WILL WE SEE THE PRODUCTS OF THESE EFFORTS?

MR. CHAIRMAN, THE STATEMENT I JUST GAVE CAME, WORD FOR WORD, FROM A SCIENCE COMMITTEE HEARING HELD NOVEMBER 26, 1979 AND FROM THE TEXT OF PUBLIC LAW 94-413, THE ELECTRIC AND HYBRID VEHICLE R&D ACT OF 1976.

THE QUESTION THAT I AND THE AMERICAN PUBLIC MOST WANT ANSWERED IS, WHAT WILL BE THE PROGRESS REPORT ON ELECTRIC VEHICLE R&D AT A SCIENCE COMMITTEE HEARING HELD 11 YEARS FROM NOW?

THANK YOU, MR. CHAIRMAN.

Mr. TORRICELLI. Mr. Packard, I understand you would like to make an opening statement.

STATEMENT OF HON. RON PACKARD, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. PACKARD. If I may, Mr. Chairman. I want to thank you for the opportunity of appearing before your subcommittee hearing.

I wish to express my strong support for the role that electric vehicle technology has in our new national energy policy and strategy. The Department of Energy's recommendations for a national energy strategy will go to President Bush in December. I would encourage the Honorable Mike Davis, who is here today representing the administration, to carry back the message that many Members of Congress are greatly concerned in regard to the cutbacks in funding for the Transportation Energy Conservation Program which funds the electric vehicle research.

Continued dependency on oil threatens our environment, both through dangerous emissions into the atmosphere and through coastline deterioration resulting from offshore drilling. Furthermore, increased dependency on foreign oil threatens our national security, and therefore the time is critical for a renewed energy policy which makes significant commitment to very clean alternative fuels, such as electricity. According to the California Air Quality Board, electricity has the potential to have the biggest benefit to air quality of any alternative fuel if it is generated in a remote area with a clean fuel.

My district lies between Los Angeles and San Diego, and Southern California has very good reason to be interested in the development of alternative fuels and vehicles. For one, the use of gasoline-powered vehicles is the single greatest contributing factor to our severe air pollution. Furthermore, with the recurring instability in the Middle East, our level of dependency on foreign oil is encouraging some to look to domestic oil resources, and I think it would be a grave mistake to, in reaction to the Iraq invasion, open up our offshore oil exploration. Rather, our Federal Government must make a renewed commitment to assist in the R&D and of the transition to alternative energy sources.

Earlier this year, this committee held a hearing in my district to discuss the technical progress of various alternative transportation fuels. At the hearing, Southern California Edison Company effectively communicated a critical message about electrically-powered vehicles. Sufficient electric vehicle technology currently exists to build more than just golf carts. Southern Cal Edison provided an electric van, as they have for this hearing, for demonstration purposes. Many of us took a ride and were very impressed and amazed, frankly, at how advanced the technology is, and here today Bob Dietch is to testify on behalf of Southern Cal Edison, and I believe that they will—they came here today in one of their electric vans.

However, several market-based barriers still hinder getting the existing technology to the marketplace. From a purely consumer point of view, the price is higher than the conventional vehicles, and there is no proven performance record. From the standpoint of

vehicle manufacturers, lack of infrastructure and the enormous initial investment in R&D makes it an unrealistic commercial venture. For both of these market-based problems, carefully designed incentives by the Government are a key.

It is critical to note that even a small-scale transition to electric vehicles would be effective. The Electric Power Research Institute estimates that replacement of just 1 percent of the vehicles registered in the United States today with electric vehicles would reduce transportation sector emissions by 160,000 tons per year from what they would otherwise be.

For these reasons, I am a cosponsor of H.R. 3852, the Electric Vehicle Technology Development and Demonstration Act of 1990, and I believe this legislation prudently provides an initial incentive to get existing electric vehicle technology into the marketplace. The enhancement of the market will, in turn, encourage increased investment by the private sector.

Many companies and auto makers, several represented here today, have already made substantial investments in electric vehicle technology. However, for large-scale marketability, great breakthroughs in battery technology must occur, and this will require substantial Government and private sector funding. With nearly two-thirds of all oil in the United States being used for transportation, the investment in alternative fuels must be made. The U.S. Government support—if U.S. Government support of this program wanes, we can only expect private investors to follow suit.

I am convinced that electric vehicle technology holds immediate as well as potentially great long-term benefits as an alternative fuel, and therefore, Mr. Chairman, I urge the continuation of both Government and private sector R&D programs in electric vehicle technology, and again I want to thank you, Mr. Chairman, for the opportunity to appear.

Mr. TORRICELLI. Thank you, Mr. Packard.

Mr. Brown, the sponsor of the principal legislation in the Congress for the advancement of electric vehicles, we would welcome your opening statement, if you would like to have one at this time.

Mr. BROWN. Mr. Chairman, thank you very much.

I echo the remarks of my distinguished colleague from California, Mr. Packard. I think that it is quite clear that the time to move forward on electric vehicles is here. The example being set by local agencies in Southern California to put up millions of dollars of their own money to promote the commercialization of electric vehicles needs to be observed and commended, and the Federal Government needs to move forward in partnership with initiatives of this sort in order to give us a viable electric vehicle commercial operation, and I ask unanimous consent to put the rest of my remarks in the record.

Mr. TORRICELLI. Without objection, and I thank you, Mr. Brown.

[The prepared opening statement of Mr. Brown follows:]

OPENING STATEMENT BY CONGRESSMAN GEORGE E. BROWN, JR.

before the

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

September 25, 1990

I would like to express my appreciation to the Chairman for his sagacity in holding a hearing on electric vehicles. Given the current clean air debate and our concern over our heavy reliance on foreign oil--fueled by the Persian Gulf crisis--this hearing is extremely timely.

Mr. Chairman, in my view H.R. 3852, the Electric Vehicle Technology Development and Demonstration Act, is intended to address two national imperatives: the urgent need to develop transportation methods that will preserve or ultimately enhance air quality and the need to develop transportation methods that can relieve our dangerous and costly reliance on imported oil.

I strongly believe that it is in the national interest for the federal government to provide whatever incentives or regulatory mandates are necessary to give American consumers the opportunity to choose the electric option. Right now, consumers do not have the choice of using electric vehicles even though they are the cleanest and one of the most viable alternatives to conventional, gasoline-powered vehicles.

In 1976, Congress enacted legislation that I sponsored which created the current Department of Energy Electric and Hybrid Vehicles program. For 14 years DOE has conducted research on battery and other related electric vehicle technologies. While these efforts have spurred interest in electric vehicles and have resulted in improvements to current battery technology, I am frustrated--to say the least--that this research has not resulted in the availability of a commercial vehicle. According to a DOE official, the federal government has expended nearly $250 million in the last 14 years to implement the electric and hybrid vehicles program. Of that amount, I am told, as much as $150 million has been dedicated to battery research and development. This is a significant investment. Where are the concrete (or should I say, commercial) results from this effort?

Several of our witnesses, Mr. Chairman, are ready to testify that we should wait until more research is done. I must say that I find that analysis rather astonishing. We can wait, we have waited, but the real question is whether it is necessary to develop the very best technology before introducing electric vehicles to the American public. I don't think so.

Today, battery technology exists which is acceptable to large niche markets. Studies show that 40 percent of commercial light duty fleet vehicles in major urban areas travel only 60 miles in any given work day. As evidenced by the response to the L.A. Initiative, a number of small, innovative manufacturers are ready and capable of producing electric vehicles for the commercial market. But they cannot do so without assistance, assistance that would be provided by the federal government under the cost-share program that would be established by the legislation which several of us have proposed.

You will hear testimony from the witnesses today about the important contributions that widespread use of EV's can make to our environment and our national energy security. DOE has even stated in a recent report that electricity is one of the top three fuels with the most potential to displace a significant portion of conventional fuels over the next 10 to 15 years. Electricity is also the most pollution free option of all alternatives under serious discussion today.

The most compelling argument for involvement by the federal government in electric vehicle commercialization is the contribution these vehicles can make to our national energy security and eliminating our trade deficit. In 1988, the U.S. transportation sector consumed nearly 25 percent more oil than was domestically produced. Before the current Persian Gulf crisis drove up the price of oil, we were purchasing an average of $50 billion worth of foreign oil annually.

Because of our apparently insatiable appetite for foreign oil, our government is currently spending one billion dollars a month on Operation Desert Shield to keep Saddam Hussein at bay. We must develop ways--immediately--to decrease this addiction to petroleum products. I believe that development and commercialization of electric vehicles can help us in this battle. I firmly believe that federal participation, through enactment of the program called for in H.R. 3852 is the best--and most immediate--means of assuring that EV's become a commercial reality.

Mr. TORRICELLI. Before proceeding to our first witness, there was recently a brief segment on ABC's "Prime Time," which I did not have the opportunity to see; other Members may not have as well. It only runs a few moments, and it provides some background on electric vehicles, and we would like to show it at this time, if we could.

Rick, if you could turn that a little bit so the audience could see the screen a little bit better, and if someone could help with the lights.

[Videotape shown.]

Mr. TORRICELLI. Thank you, ABC, for that testimony.

If we could begin with our first panel, please: Assistant Secretary Michael Davis, Conservation and Renewable Energy, Department of Energy—Mr. Davis.

Mr. Davis, welcome and thank you for offering your testimony today. We will, of course, include it in the record in its entirety, but we would welcome you to provide us with any summary or review of your testimony that you would like to give to the committee at this time. Please proceed.

STATEMENT OF HON. J. MICHAEL DAVIS, ASSISTANT SECRETARY, CONSERVATION AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY, ACCOMPANIED BY ALBERT CHESNES, DEPUTY ASSISTANT SECRETARY FOR TRANSPORTATION TECHNOLOGIES

Mr. MICHAEL DAVIS. Thank you, Mr. Chairman. I will summarize my testimony.

I would also like to introduce my associate, Al Chesnes, who is my Deputy Assistant Secretary for Transportation Technologies.

Mr. TORRICELLI. Welcome.

Mr. MICHAEL DAVIS. He is here today, I think, which will help us be more responsive to your request.

I do appreciate you calling this hearing and, as you indicated, well in advance, and I think you have set the stage very well for an important topic.

Electric vehicles are one of several alternative fuel technologies under development with support of DOE and would allow the transportation sector to meet some of its energy demand with electricity and reduce the sector's high demand for petroleum fuels.

The promise of improved urban air quality is another principal attraction of electric vehicles. The vehicles will be essentially nonpolluting if they use electricity generated from solar, hydroelectric, or nuclear energy. Even using electricity generated from some combination of coal, natural gas, or oil, electric vehicles would still effect a major reduction in most emissions caused by the transportation sector except CO2.

The Department presently is pursuing a broad-based research, development, test, and evaluation program in electric vehicle technologies with emphasis on battery and fuel cell R&D, propulsion system development, and laboratory and fuel testing.

In battery research, we are concentrating our efforts on the three most promising advanced battery candidates: sodium sulphur, zinc bromine, and lithium metal sulfide. Battery research, formerly conducted under the Renewable Energy Program, has

been transferred to the transportation sector. This will enable us to focus the basic research activities being conducted in DOE laboratories directly on the fundamental problem areas that currently are limiting battery life and performance and, as a result, provide us with a stronger electric vehicle program.

Fuel cells operating on nonpetroleum fuels can potentially provide a propulsion system alternative with nearly twice the fuel economy and greatly reduced emissions compared with the internal combustion engine. The Department is pursuing two systems, a phosphoric acid fuel cell system for the year 1995 to 2000 time frame, and a fuel cell that utilizes a proton exchange membrane for beyond the year 2000.

In the area of electric vehicle test and evaluation, we are continuing to apply laboratory and in-vehicle dynamometer testing to the advanced battery cell modules and vehicle systems from the R&D program and other sources. We are also supporting the field testing of new electric vehicles through cost-shared programs with private and public utilities and State and local governments.

With current battery technology, electric vehicles are not economically competitive. However, with advancement in battery technologies, they will become more competitive, especially on a life cycle cost basis, because of their potential for much lower operating costs. Our battery development program is concentrating on advanced technologies that will provide electric vehicles with a reliable operating range of well over 100 miles. Within the next five years, we will be field testing prototype passenger cars and light vans that will be capable of a 150-mile range on a single battery charge. By the late nineties, we expect to have commercially available electric vehicles with a range capacity in excess of 200 miles on a single battery charge.

Hybrid systems have been ignored in recent years but deserve a second look in view of recent advancements in technologies such as power electronics and devices such as ultracapacitors. In the near term, a hybrid, with a small on-board engine generator unit for battery charging, could eliminate the range limitation with current battery technologies and not only accelerate the time period for commercialization of electric vehicles, but also greatly expand the potential market. DOE is examining the range extender concept as well as other hybrid approaches to determine if there are technology problems that require Government research and development support.

DOE is working cooperatively with other organizations, such as the Electric Power Research Institute, and private and public utilities, including Southern California Edison, the Los Angeles Department of Water and Power, Arizona Public Service, and GTE, to name just a few, to accelerate the development and commercialization of electric vehicles.

With regard to the legislation, H.R. 3852 essentially would provide subsidies for the commercialization of electric vehicles through cost discounts to the consumer, that would make either the life cycle cost or the purchase price match the comparable cost of a conventionally-fueled vehicle. The intent is that these subsidies would enhance the marketability of electric vehicles to the point where the increased demand would lower the vehicle price as a

result of the economies of scale associated with mass production. However, it is unlikely that the economies of scale necessary to obtain the desired decrease in production costs will be achieved as a result of subsidies. The price differential for vehicles that currently are being considered for production is much too great to achieve a significant increase in volume without a major drain on the Treasury. Accordingly, we oppose the bill.

The legislation would also conflict with the Alternative Motor Fuels Act which calls for the development of recommendations for policy to commercialize alternative fuels, including electric vehicles. We believe that the Interagency Commission on Alternative Fuels established by AMFA should be allowed to complete its work on schedule—on the schedule called for in AMFA and to make its recommendation before Congress enacts legislation singling out certain fuels for special treatment.

The Department has a program in place, supported by Congress, to cost share in the purchase of new vehicles and related technologies for field testing through the user task force. This program is not only providing valuable information to our program, but is also enabling large and small fleet operators to become acquainted with electric vehicles and identify weaknesses and deficiencies that must be corrected before the vehicles are widely distributed to the general public.

The course of action that our program is currently on, coupling aggressive research and development with laboratory and field testing of new technologies, is well founded and will result in the early commercialization of viable electric vehicles. That will assist in our efforts to reduce our Nation's dependency on imported petroleum. Premature commercialization resulting from creation of artificial markets through the use of subsidies can be detrimental to the introduction of new technologies.

I thank you for the opportunity and will respond to your questions.

[The prepared statement of Mr. Michael Davis follows:]

Statement of J. Michael Davis
Assistant Secretary, Conservation and Renewable Energy
U.S. Department of Energy

Committee on Science, Space, and Technology
Subcommittee on Transportation, Aviation, and Materials
U.S. House of Representatives
September 25, 1990

Mr. Chairman and members of the Committee:

I appreciate the opportunity to discuss the DOE program on electric vehicle research and our views on H.R. 3852, the "Electric Vehicle Technology Development and Demonstration Act of 1990."

In 1989, the transportation sector of the U.S. economy used 22.2 quadrillion Btus (quads) of energy, almost entirely in the form of petroleum. The sector consumed approximately 10 million barrels of petroleum per day, accounting for 27 percent of all energy used and 63 percent of all petroleum consumed in the United States. Indeed, the transportation sector used 33 percent more oil than the U.S. produced in 1989.

Electric vehicles, one of several alternative fuel technologies under development with support from DOE, would allow the transportation sector to meet some of its energy demands with electricity and reduce the sector's high demand for petroleum fuels. Only 5 percent of electricity is generated from petroleum, with the balance generated using other energy resources including renewables. By way of illustration, a market penetration by electric vehicles in today's vehicle stock of 10 percent in automobiles and 15 percent in light duty trucks and vans would result in the substitution of 1.6 quads or 292 million barrels of

petroleum per year. However, this level of penetration is probably not achievable until the year 2000-2010 time frame .

The promise of improved urban air quality is another principal attraction of electric vehicles. These vehicles will be essentially nonpolluting if they use electricity generated with solar, hydroelectric, or nuclear energy. Even using electricity generated from some combination of coal, natural gas, or oil, electric vehicles would still effect a major reduction in most emissions caused by the transportation sector, except perhaps CO_2.

In the testimony that follows, I would like to first inform you of the status of the Department's Electric and Hybrid Vehicles Program, followed by our perspective on when these technologies could become available in the commercial marketplace, and lastly, provide comments on the legislation.

Summary of DOE Electric and Hybrid Vehicle Program

The Department presently is pursuing a broad based research, development, test, and evaluation program in electric vehicle technologies with emphasis on battery and fuel cell R&D, propulsion system development, and laboratory and field testing.

In battery research, we are concentrating our efforts on the three most promising advanced battery candidates, sodium-sulfur, zinc-bromine, and lithium-metal sulfide. Other battery couples for which we have ongoing contracts include advanced lead-acid and nickel-iron for the near term and iron-air and sodium-metal chloride for the longer term. In addition, a basic research component in

support of these development activities is now being conducted within the Electric and Hybrid Vehicles Program. This is a result of our recent reorganization where activities were realigned to eliminate overlap and duplication, and basic battery research formerly conducted under the renewable energy program was transferred to the transportation sector. This will enable us to focus the basic research activities being conducted in the DOE laboratories directly on the fundamental problem areas that currently are limiting battery life and performance, and as a result, provide us with a stronger electric vehicle program.

A sodium sulfur battery developed by Chloride Silent Power Ltd. was delivered recently to the Ford Motor Company where it currently is undergoing tests with the ETX-II vehicles. Earlier dynamometer tests with this vehicle and battery combination produced a range of 150 miles over the Federal Urban Driving Cycle. The battery and vehicle will be delivered to our test facility at the Idaho National Engineering Laboratory next month to be subjected to more testing.

The contract for the development of the single shaft alternating current propulsion system for the ETX-II vehicle has just been completed by the Ford Motor Company. We will be conducting a final review of that program in a few weeks. A contract for the next phase, which involves the development of modularized versions of the propulsion system that will be suitable for a broad range of vehicle sizes, was just signed last week. This phase will conclude the Government's involvement in this program and will result in the delivery of three different sizes of prototype vehicles with the advanced batteries, vehicles, and propulsion systems designed and developed as integral units. This will be a

major step in bringing this technology to the point where it can be mass produced by industry.

Fuel cells, operating on non-petroleum fuels, can potentially provide a propulsion system alternative with nearly twice the fuel economy and greatly reduced emissions compared with internal combustion engines. The Department is pursuing two systems, a phosphoric acid fuel cell system for the year 1995-2000 time frame and a fuel cell that utilizes a proton exchange membrane for beyond year 2000.

The objective of the phosphoric acid program is to develop a fuel cell/battery propulsion system suitable for a 30 foot urban bus. The first phase of this program, which involved the development and test of 1/2 scale brassboard fuel cell systems for laboratory testing, has been successfully completed. The design studies and impartial test results verified the feasibility of the phosphoric acid system for the small bus application, and a competitive procurement for the second phase is underway. The second phase will culminate in the delivery of three prototype buses in 1993.

A contract for the development of a proton exchange membrane (PEM) fuel cell was recently signed with the Allison Division of General Motors. This will be a four phase program with Phase I, Feasibility Evaluation, leading to the demonstration of a 5 Kilowatt (kW) breadboard system. Phase II will be directed at proving feasibility by means of a 25 kW brassboard system, and Phase III will result in the laboratory evaluation of a full-scale 50 kW propulsion system. In the final phase, a full scale system will be installed and evaluated in a van or

passenger vehicle. The PEM is a more difficult technology to develop, but the potential payoff is much greater because of its applicability to a broader range of vehicle sizes due to its reduced size and weight compared with other fuel cell systems. In addition, it will have a faster start-up time, provide better transient response, and have the potential for lower costs.

In the area of electric vehicle test and evaluation, we are continuing to apply laboratory and in-vehicle dynamometer testing to the advanced battery cells, modules, and vehicle systems from the R&D program and other sources. We are also supporting the field testing of new electric vehicles through cost shared programs with private and public utilities and state and local governments. In the past few months we have been contacted by a number of state and local governments as well as other organizations expressing an interest in participating in our field test program. Consequently, we are in the process of initiating a competitive solicitation from which we will select additional sites for evaluating electric vehicle technologies.

Prospects for Electric Vehicles

With current battery technology, electric vehicles are not economically competitive. However, with advancement in battery technologies, they will become more competitive, especially on a life cycle cost basis because of their potential for much lower operating costs.

Our battery development program is concentrating on advanced technologies that will provide electric vehicles with a reliable operating range of well over

100 miles. Within the next five years we will be field testing prototype passenger cars and light vans that will be capable of a 150-mile range on a single battery charge. By the late 1990s we expect to have commercially available electric vehicles with a range capability in excess of 200 miles on a single battery charge.

Hybrid systems have been ignored in recent years but deserve a second look in view of recent advancements in technologies such as power electronics and devices such as ultracapacitors. In the near term, a hybrid, with a small on-board engine/generator unit for battery recharging could eliminate the range limitation with current battery technologies and not only accelerate the time period for commercialization of electric vehicles, but also greatly expand the potential market. DOE is examining the range extender concept, as well as other hybrid approaches, to determine if there are technology problems that require Government research and development support.

DOE also is working cooperatively with other organizations such as the Electric Power Research Institute (EPRI) and private and public utilities including Southern California Edison, the Los Angeles Department of Water and Power, Arizona Public Service, and GTE, to name just a few, to accelerate the development and commercialization of electric vehicle technologies. EPRI is supporting the development and production of the General Motors G-Van as well as the Chrysler TEVan. DOE and EPRI jointly funded the early phases of the TEVan development and are cost sharing in some battery development activities. EPRI recently signed a contract with Eagle-Picher Industries in Joplin, Missouri, to build a pilot plant for the production of nickel-iron batteries, beginning in

1992. The development of the nickel-iron battery has been funded by the DOE program for the past several years.

The DOE and EPRI programs are synergistic, with DOE focusing on advancing the technology through research and development, and EPRI and the electric utilities concentrating their efforts more towards early commercialization.

H.R. 3852

With regard to the legislation, H.R. 3852 essentially would provide subsidies for the commercialization of electric vehicles through cost discounts to the consumer that would make either the life cycle cost or the purchase price match the comparable cost of a conventionally fueled vehicle. The intent is that these subsidies would enhance the marketability of electric vehicles to the point where the increased demand would lower the vehicle price as a result of the economies of scale associated with mass production. However, it is unlikely that the economies of scale necessary to obtain the desired decrease in production cost will be achieved as a result of subsidies. The price differential for vehicles that currently are being considered for production is much too great to achieve a significant increase in volume without a major drain on the Treasury. Accordingly, we oppose the bill.

This legislation would also conflict with the Alternative Motor Fuels Act (AMFA), which calls for the development of recommendations for a policy to commercialize alternative fuels, including electric vehicles. We believe that the Interagency Commission on Alternative Fuels, established by AMFA, should be

allowed to complete its work on the schedule called for in AMFA, and to make its recommendation before Congress enacts legislation singling out certain fuels for special treatment.

The legislation requires the cost subsidy to be determined on the basis of the difference in life cycle cost or purchase price between an electric vehicle and a conventionally-fueled vehicle of comparable type. Determining a "comparable type" vehicle will be difficult and subjective, especially if the manufacturer chooses to market a totally new vehicle design rather than convert an existing chassis to electric propulsion. There are any number of vehicles within a major manufacturer's inventory of models that would have similar features, such as passenger and cargo capacity, weight, etc. The manufacturers would want to select the comparable vehicle with the lowest price to maximize the subsidy, and the Government would want the highest price to minimize the subsidy. There would be a constant debate, between the manufacturers and DOE as to what the proper subsidy should be.

Additionally, it would not be possible to utilize life cycle cost as an accurate basis for determining subsidy values without collecting years of data. Life cycle cost is a function of many variable costs, especially maintenance and battery life. Without considerable real world data these values can only be estimated. Maintenance costs would be extremely difficult to determine. New products typically have high initial maintenance until the product becomes more mature. This will tend to distort the initial life cycle cost of the electric vehicle. Battery life also is likely to be significantly different in the field than in laboratory tests due to

variations in battery charging schedules, maintenance procedures, climatic conditions, etc. These two parameters strongly influence life cycle cost and will not be known with any degree of certainty until a statistically significant number of vehicles have experienced a full life cycle.

The Department has a program in place, supported by Congress, to cost share in the purchase of new vehicles and related technologies for field testing through the User Task Force. The User Task Force consists of a group of electric utility companies and other organizations that are interested in the commercialization of electric vehicles and are under contract to DOE. This program, is not only providing valuable information to our program but is also enabling large and small fleet operators to become acquainted with electric vehicles and identify weaknesses and deficiencies that must be corrected before the vehicles are widely distributed to the general public.

The course of action that our program is currently on, coupling aggressive research and development with laboratory and field testing of new technologies, is well founded and will result in the early commercialization of viable electric vehicles that will assist in our efforts to reduce our Nation's dependency on imported petroleum. Premature commercialization resulting from the creation of artificial markets through the use of subsidies can be detrimental to the introduction of new technologies. Accordingly, the Department opposes this legislation.

Thank you for the opportunity to appear before you. I would be pleased to answer your questions at this time.

Mr. TORRICELLI. Thank you, Mr. Davis.

I assume from your testimony that the general view of the Administration is that the concept of adjusting the market factors through taxes or subsidies to advance the market potential of electric vehicles as a general proposition remains unacceptable to the administration.

Mr. MICHAEL DAVIS. I think the way I would respond to that is, as a part of the national energy strategy, there is no question but we have to address the transportation sector and the various alternatives and approaches to reduce the consumption of petroleum. That work has been underway, electric vehicles are a part of that, and there are a number of very important options that we have to develop, and as we do, we will put those forward to the President. Electric vehicles are a part of that.

There are other measures that also may well be a part of that, which would include various ways to address the market, either in terms of removing disincentives or in terms of incentives that might also be timely and powerful, given a particular technology.

Mr. TORRICELLI. But the thrust of the question is whether, as this committee or others in Congress generate ideas to advance that market potential by adjusting the market, you remain open to those ideas or you believe that the Government should not in any case try to adjust the market.

Mr. MICHAEL DAVIS. I think we are certainly open to those ideas.

Mr. TORRICELLI. I do not generally understand why, even at this date, when we recognize that 40 percent of our light commercial vehicles in the areas with the worst air quality problems are traveling less than 60 miles a day, there is not an immediate light truck market, as there is not an immediate second and third suburban vehicle market, for that large segment of the driving and commercial public which is traveling within these distance limitations. Why does that market not now exist?

Mr. MICHAEL DAVIS. I think there is—the market as you describe it does exist. There is an opportunity to meet those needs, and potentially electric vehicles could do that. The question is, is there somewhere where the consumer could buy those and buy them with some assurance of cost and performance? and the answer to that is, right now, I don't believe there is widely available opportunities for the consumers to do that.

Mr. TORRICELLI. Consumers can't buy a product that doesn't exist, and many manufacturers are not going to begin making a product unless there is some assurance that the market factors will continue to support its sales. That returns us to the policies of Government. I presume an auto company which was able to calculate what a long-term price of oil might be, with some assurance that an infrastructure was going to be available to support these vehicles, might recalculate their marketing judgments with more confidence. That isn't going to happen in the marketplace; that happens because of Government policy.

Mr. MICHAEL DAVIS. I think our objective—and I think it's a shared objective—is that we would like to be successful and we would like to have policies that, we think in the long term, are actually going to hold up.

I think what wasn't mentioned in that video and does need to be mentioned—everybody was sitting there with the idea in their pocket that we were looking at $30, $40, and $50 a barrel oil, which indeed didn't happen, and we basically went down in our cost of oil. That wasn't necessarily controllable by any of the entities that were responding to those questions, and with that decrease in the cost of oil, it is clear where the consumer went.

Mr. TORRICELLI. Well, Mr. Davis, this is not the place to debate it, but, on the contrary, the fact that the price of oil went down to $9, and $12, and $14 a barrel was a judgment very much made by OPEC, and particularly by the Saudis in OPEC, to drive other sources out of the oil business. The United States Government may have chosen not to be involved in the decision for our own national interests, but others defended their national interests very well.

This is not an energy hearing, so we won't go into it at length. Suffice it to say, the price of oil did not have to go to $9 a barrel, and if we had a national concept of energy and a transportation concept which wanted to encourage electric automobiles and we believed that to do so a $25-a-barrel price of oil was necessary during the last decade, we could have done that as a government and we could have moved the marketplace in the right direction. We chose not to do so; to do so was not impossible.

In any case, that is my statement for the day on the oil industry.

On electric vehicles, why then, given the comparable cost of operation and these ranges, with so many of these vehicles in these—driving these short distances, why is there not an immediate market then?

Mr. MICHAEL DAVIS. I think there's two primary issues. One is the availability of vehicles, and there would seem to be a market size there that is substantially below the interest of the large manufacturers. I think the market size that you describe is very interesting to smaller manufacturers or people that might want to enter into this business now and produce a vehicle.

Mr. TORRICELLI. Will a large American company, not necessarily one of the three auto makers today—how many units, in your judgment, have to be produced for a company to feel that it is worth it to begin production of a light utility van, for example?

Mr. MICHAEL DAVIS. Are you referring to a large company, how many vehicles would—

Mr. TORRICELLI. Yes, a Fortune 500 American company, seeing this battery technology and looking at this marketplace. How many units do you think they would have to be convinced can be sold in the marketplace before it is worth making the investment—annual units?

Mr. MICHAEL DAVIS. Well, you certainly have more expertise that will testify following me than my own, but I think that from a large company point of view it would be, I think, numbers of 100,000 vehicles a year have been put forward as the level of market that is necessary.

Mr. TORRICELLI. And it is your judgment that the Department has looked at this, and the combination of local governments, State governments, Federal Governments, local delivery services, utilities—is it your judgment that there are not 100,000 annual sales

today available if the cutting edge of this technology at current costs were made available? Do you share that market judgment?

Mr. MICHAEL DAVIS. I think if there was a high degree of certainty as to the vehicle and the performance of the vehicle, that indeed there is a market that would aggregate above 100,000 vehicles.

Mr. TORRICELLI. That is my judgment as well.

Based on the Federal work today on improving battery efficiency, are you forecasting any significant increases in battery efficiency in the next five to 10 years, or is it going to be incremental progress?

Mr. MICHAEL DAVIS. We have actually prepared a chart which describes the different battery pairs starting in 1979, where they were and where we think they are now, and I would like to submit that for the record to give you a more detailed answer.

[The material referred to follows:]

INSERT FOR THE RECORD

Battery Progress

Question: Are you forecasting increases in battery efficiency over the next five to ten years?

Answer: The attached chart illustrates the progress we have made in our battery development program and also presents the goals that we expect to achieve in the next five to ten years. The nickel/iron battery is now entering the pilot plant production phase. The Electric Power Research Institute recently signed an agreement with Eagle-Picher Industries to build a pilot plant for producing this battery. This plant is expected to be completed in 2 years. DOE is supporting this effort by concentrating on methods of reducing the cost of the nickel electrode to improve battery marketability.

The major focus of the DOE battery R&D program is on sodium/sulfur, zinc/bromine, and lithium aluminum/iron sulfide. It is our opinion that these battery candidates currently have the greatest potential for satisifying the range and performance requirements that will make electric vehicles viable over the long term. However, a modest level of basic research is being conducted on other battery technologies that are higher risk but have the potential for greater pay-off if the current barrier problems can be resolved.

Mr. TORRICELLI. I would appreciate your doing so, but do you have a forecast that you would anticipate in the remainder of the next five to 10 years of where you believe this efficiency can go?

Mr. MICHAEL DAVIS. I think there's incremental improvement. I don't think that we are looking at, with respect to batteries, major breakthroughs. I think with respect to fuel cells we may have had a couple of major breakthroughs.

[The chart follows:]

PROGRESS IN EV BATTERY DEVELOPMENT

Battery	Specific Energy (wh/kg) 1979		1990	Specific Power (w/kg) 1979		1990	Cycle Life to 80% DOD (cycles) 1979		1990
Lead/Acid (Pb/A)	42[c]		53[m]	75[c]		104[m]	250[c]		130[m]
(BG)		56			79				450
Nickel/Iron (Ni/Fe)	40[m]		50[m]	100[m]		108[m]	1000[m]		1100[m]
BG		56			79				1125
Zinc/Bromine (Zn/Br_2)	20[m]		55[b]	15[m]		88[b]	10[m]		142[b]
BG		75			79				600
Lithium Aluminum/ Iron Sulfide (Li Al/FeS)	100[c]		90[m]	45[c]		86[m]	286[c]		130[m]
BG		100			106				600
Sodium/Sulfur (Na/S)	110[c]		96[m]	25[c]		130[c]	NA		261[m]
BG		100			106				600
Iron/Air (Fe/Air)	NA		70[c]	NA		90[c]	NA		120[c]
BG		100			106				600

NOTES: c= Cell data, m= Module data, and b= Battery data
BG= Battery Goals for mid 1990's as given in the DOE report #DOE/CE-148 (Rivision 1), November 1987.

Mr. TORRICELLI. Do you have some judgment on what kind of oil prices would, in fact, change some of the market dynamics and competition today? Is there any number that you peg as significant in tipping the competitive factors?

Mr. MICHAEL DAVIS. Sustained—sustained high levels.

Mr. TORRICELLI. Sustained high price, the kind of sustained high price, for example, if the Administration accepted an oil import fee, not to mention what it would do in getting us through the next few weeks.

How about the prospects of a consortium of American companies joining together to do research in this? Does the Administration have a position on that?

Mr. MICHAEL DAVIS. That is something that we are actually looking forward to, and we think the potential for that is substantially better than it has been in the past. DOE has done and supported, with Congress's encouragement, a fairly broad battery research program. This year, for the first time, we have brought forward a budget that focused on a selected number of pairs, because we thought that was the best potential, and as we have received the appropriation mark back, indeed that mark retained that focus.

Now, given the current situation, there is substantially more interest in the private sector in working jointly with the Federal Government, and I think that is fundamentally important. I think if DOE does research all by itself in the laboratory, we are going to do that for a long time and never probably be as effective.

Mr. TORRICELLI. But the concept of these companies, indeed, either among auto companies or other technology companies with auto companies wanting to do this on a consortium basis, you do not—you are not presenting here today any ideological barriers to doing so?

Mr. MICHAEL DAVIS. No. We think that is a good idea, and, in fact, we are trying to encourage it.

Mr. TORRICELLI. And, finally, before we break for this vote, how would you rate America competitively with international—with other international players in the automotive business today in battery and other aspects of electric vehicle development?

Mr. MICHAEL DAVIS. I wouldn't say that we have a lead.

Mr. TORRICELLI. You would not.

Mr. MICHAEL DAVIS. I would not.

Mr. TORRICELLI. Would you say that others have a lead?

Mr. MICHAEL DAVIS. I'd say we don't have the lead.

Mr. TORRICELLI. Okay. And where is this principal competition coming from? Dare I ask, if I don't know.

Mr. MICHAEL DAVIS. I think the—I don't have the most accurate information that I'd like to have on the Japanese market. I think certainly the European market has—has begun to position itself better in terms of bringing these technologies forward.

Mr. TORRICELLI. From major auto companies?

Mr. MICHAEL DAVIS. I think there are utility involvement, there are battery company involvement, and there are also auto company involvement.

Mr. TORRICELLI. And how about the level of European government involvement? Have they been the result of government development or principally from the companies themselves?

Mr. MICHAEL DAVIS. I think principally from companies themselves heretofore.

Mr. TORRICELLI. The Japanese apparently do have a vehicle they are going to put on display in Hong Kong at the EV show that is taking place there, which apparently is competitive.

The committee will adjourn for just a few moments for this vote, and we will return then for Mr. Lewis's questioning.

Thank you, Mr. Davis.

Mr. MICHAEL DAVIS. Thank you, Mr. Chairman.

[Recess.]

Mr. TORRICELLI. The committee will come to order.

Mr. Davis, thank you for your patience.

Mr. Brown.

Mr. BROWN. Thank you, Mr. Chairman.

Mr. Davis, I had the privilege of participating in the development of the Electric and Hybrid Vehicle Act of 1977, I think it was, which is 13 years ago, and one of the purposes of that Act was to get the kind of data that you referred to on life cycle costs and maintainability and some of the other things of that sort, and in connection with that program several thousand vehicles were purchased and used for years by the Post Office and the telephone company and other major utilities. Do I understand from your testimony that none of the data that they collected is usable today?

Mr. MICHAEL DAVIS. Mr. Brown, I'm not suggesting that that data isn't usable, but I am suggesting that the technology has evolved substantially. We have a user task force. That task force is largely comprised of entities that are very important to bringing commercial vehicles forward in the private sector. They are collecting much of that data for us, and I think you will hear from them, and you will hear from a couple of them this afternoon, as to what data is available and what data is needed.

By topic, I think we have the data, but in terms of saying, do we have the data to accurately figure out how to manage this incentive program, I don't think we do have that data, no.

Mr. BROWN. You can understand my feelings, having participated in this first generation activity many years ago, and having been told at that time that the feasibility of a commercially available electric vehicle was 10 years away, and 13 years later being told the same thing, and having it explained as a result of not having the data available that was supposed to have been collected then, in part at least.

I understand the technology's development—is developing. We had always expected that it would develop. It seems to be having difficulty catching up with the future, apparently.

I don't want to belabor that point, because our purpose, of course, is to see what we can do today to bring about the commercial availability.

You say in your testimony that the Department has a program in place, supported by Congress, to cost share in the purchase of new vehicles and related technologies for field testing through the user task force, and I commend you on that, as a matter of fact. I would like to have you tell me what is the distinction between providing a subsidy and sharing the costs.

Mr. MICHAEL DAVIS. I think there are a couple of clear distinctions. The user task force involves entities that would either provide the power or, in some cases, operate the fleets, as opposed to the individual consumer. I think that's one important difference.

We can, through the user task force, constantly provide for the integration of new technology, as a particular controller or battery or whatever. The minute we actually have technology in our hands that we can apply, we can immediately put it into that program. We can do it in a very controlled way, and we can get the information essentially in the hands of people that would make much larger decisions concerning either the provision of electric vehicles or the acquisition of electric vehicles. So we think we are working in an area that simply has better leverage than the individual consumer.

Secondly, I would like to add that I think the incentive idea—we're not saying it's a bad idea, but there is a question, a legitimate question, of timing, and what we are really saying is that we think the technology focus on batteries right now, given the very constrained budget situation, is the best buy today, but I wouldn't say that we are necessarily opposed to ways to help markets develop. It's a matter of timing, it's a matter of budget constraint, and it's a matter of where we think the best buy today is in terms of electric vehicles.

Mr. BROWN. I'm going to ask you in a minute what some of the other strategies might be to produce that commercial market, but before I do that, I want to ask you another question.

Obviously, during the last decade, the Federal support for research, development, and commercialization of electric vehicles has fallen off rather dramatically. Is that a factual statement?

Mr. MICHAEL DAVIS. I think a decade ago we had a much broader program. There were elements of information and market development, various programs in addition to the R&D, and it is clear that those programs were reduced then to a focus on the longer-term R&D. That's indeed accurate.

Mr. BROWN. Would you speculate as to whether or not we would have overcome some of the obstacles that you present to commercialization today if we had maintained a level or increasing level of effort over this last decade?

Mr. MICHAEL DAVIS. I think—

Mr. BROWN. I'm not holding you responsible for any of this.

Mr. MICHAEL DAVIS. No, sir, I understand, and I think that my own view on this is, had we maintained a larger level of effort and—and this is a very important "and"—and had we had the direct involvement, the positive relationship between Government and industry that I think we need to bring products forward quickly—if we would have had both of those two working together, higher level of Government support and a much more direct and even cost-shared level of interest from the right private sector players, then indeed we would be further down this road.

Mr. BROWN. So what we have today is a much smaller level of Federal effort, but you are pointing to the cost-sharing program as holding out hope for the future in a more effective way than a subsidy program.

Mr. MICHAEL DAVIS. I think that the cost sharing is important, but I think it is fundamental that we have the right players participating in the program.

Mr. BROWN. I presume the right players would include the major automobile companies, and I would like to ask you, did you see any vision of hope from the statements that were on the television and other statements, which I presume will be repeated a little later by other witnesses, that they are going to move aggressively into this area?

Mr. MICHAEL DAVIS. I'm hopeful today that in your questioning you will get a little bit more specific answers in terms of objectives and timing.

Mr. BROWN. Believe me, we will.

Now, in addition to the kinds of incentives that we have been using and are proposing to use, you are pointing to the cost-sharing program and the users task force. Of course, I am pointing to the legislation which provides for some subsidy incentives. Are there other strategies? For example, could we mandate a certain proportion of electric vehicles, or could we give—in each manufacturer's fleet—could we provide a prohibitive combined average fleet efficiency level of which—and then give them a big bonus for electric vehicles, which would be the only way they could meet that? Are there some combination of additional incentives that might prove useful, maybe more specifically, involving high pollution areas, for example?

Mr. MICHAEL DAVIS. I think we need to keep our eye carefully on incentives.

Mr. BROWN. Let me just say this. I have worked for the automobile companies for 25 years. I have never seen them do anything they didn't have to do; believe me.

Mr. MICHAEL DAVIS. Well, I would—as a former small businessman that was run over financially by changes in public policy, I think we need to look at incentives very carefully, and if we commit to any of them, we have got to commit to them for a long enough period of time that they actually affect investment.

Mr. BROWN. Correct.

Mr. MICHAEL DAVIS. But I would say that our view of the technology today is such that we have got to bring that technology along before I think we could select appropriate and enduring incentives. I just think it is so important that the timing of having the technology available and also the incentives that may well be needed match. If they don't, we are liable to do more damage than we do good.

Mr. BROWN. That is not very persuasive to me when I have seen the commercial use of electric vehicles in delivery fleets, as was pointed out in the video there, for decades. The automobile companies just don't choose to enter that market. They will choose to build an Edsel, but they will not choose to enter that market, and we have to be more persuasive than we have been in the past.

Now I love the automobile companies—you can tell from my remarks—I even buy automobiles once in a while, and I am just looking for a strategy which will appeal to them, a large club preferably.

Thank you, Mr. Chairman.

Mr. TORRICELLI. Thank you, Mr. Brown.

Before I recognize Mr. Rohrabacher, Mr. Davis, in the CAFE standards—the automobile mileage standards—if a domestic producer produces an electric automobile today, does that count simply as zero against the average?

Mr. MICHAEL DAVIS. I believe, and I'll check this for the record, Mr. Chairman, but there is provision for alternative fuel or flexible fuel vehicles. It may be alternative fuel, I will have to check that, but I believe that the maximum benefit of that is 1.2 miles per gallon increase in average for that vehicle class. I will have to check that.

[The material referred to follows:]

INSERT FOR THE RECORD

Corporate Average Fuel Economy

Question: What CAFE credits can automobile manufacturers get for producing electric vehicles?

Answer: The application of electric vehicles to the Corporate Average Fuel Economy was initiated by the Chrysler Corporation Loan Guarantee Act of 1979. This Act amended the Motor Vehicle Information and Cost Savings Act and directed the Secretary of Energy to determine equivalent petroleum-based fuel economy values for various classes of electric vehicles. Legislation was passed in 1981 (10 CFR Part 474) that provided the method of calculating the equivalent fuel economy and the petroleum equivalency factors for vehicle model years 1981 through 1987. The petroleum equivalency factor, one factor in the equivalent fuel economy equation, is based on statistics from the Electric Utility Industry and the marginal price of gasoline. The Department of Energy is preparing an update to 10 CFR Part 474 that will allow the petroleum equivalency factor to be published on an annual basis starting with vehicle model year 1992. Projections for equivalent fuel economy values based on current statistics are: full size van (GM G-Van) 54 mpg, mid-size van (Ford ETX-II) 132 mpg, and a small passenger car (GM Impact) 308 mpg.

Mr. TORRICELLI. But, indeed, among the many incentives we could give would be to adjust that formula to multiply it in some way so that companies can be permitted higher consumption of gasoline in some of their vehicles in some ratio if they reach a threshold of electric vehicles.

Mr. MICHAEL DAVIS. I think with respect to alternative fuels that is a very important aspect of CAFE and ought to be looked at closely.

Mr. TORRICELLI. Is that a concept which you in any way find alien or unacceptable conceptually?

Mr. MICHAEL DAVIS. No. In fact, that aspect of CAFE is something we have got under analysis.

Mr. TORRICELLI. Thank you, Mr. Davis.

Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you very much, Mr. Chairman.

Mr. Davis, will an electric car—will it actually save energy for this country? I mean something has to produce the electricity. Is the energy that is used up in producing the electricity, is that an overall savings from just having the fuel pumped directly into the automobile?

Mr. MICHAEL DAVIS. Well, it certainly appears that if the power is coming from a central plant, that a central generating plant is indeed more efficient that most of the internal combustion engines that are on board, so that from a net energy point of view, electric vehicles can compete.

Mr. ROHRABACHER. So in terms of the energy use of the United States of America, if our cars now were basically electric cars rather than internal combustion engines that use gasoline, there would be a net fuel savings in oil for the United States of America?

Mr. MICHAEL DAVIS. I wouldn't make—we are displacing, obviously—we are displacing oil for another form of energy. So while we would be saving oil, we would obviously be consuming energy of another type to produce that electricity.

Mr. ROHRABACHER. That's right.

Mr. MICHAEL DAVIS. But I thought your point initially was, from a net energy point of view, can an electric vehicle from primary energy to a delivered service be as efficient as a gasoline-powered—

Mr. ROHRABACHER. No. I'm talking about whether or not our country is going to be better off in terms of our energy independence because we are producing electricity and then putting it into our automobiles and the oil, or whatever it is, that is necessary to produce that electricity versus having the internal combustion engine just independently producing energy in a car by using gasoline.

Mr. MICHAEL DAVIS. Well, if it's a choice between domestic coal and oil imported from an unstable part of the world, I think, pretty clearly, it's clear today how that vote would come out.

Mr. ROHRABACHER. Do we have enough electric energy to provide the energy necessary for a large number, maybe 50 to 60 percent of our automobiles? If those same automobiles that are now gasoline automobiles would be run on electricity instead of gasoline? Do we have that electric capacity?

Mr. MICHAEL DAVIS. Let me approach it—let me try and answer your question this way. Even assuming very, very aggressive levels

of penetration, we have enough electricity, if you look at the national availability of electricity, to meet whatever would be projected as the next 10 years, say, for electric vehicles. But that is a bit of a misleading answer.

Mr. ROHRABACHER. Yes, it is.

Mr. MICHAEL DAVIS. And the reason is that you have to look very specifically within certain markets in terms of what is the availability of electricity within a particular market area and what other measures are also competing for that electricity, which is certainly becoming the fuel of choice.

Mr. ROHRABACHER. And we are not just talking about what is projected in the use of electric cars, we are talking about, what if we actually had a significant number of automobiles in this country—50 percent or 60 percent of the automobiles—run on electricity? I have my doubts whether or not we have the electric capacity to handle that, and they aren't going to be building any more electric plants in Southern California; I'll tell you that much.

Mr. TORRICELLI. If the gentleman would yield.

Mr. ROHRABACHER. Yes, sir.

Mr. TORRICELLI. It is important to remember that a lot of this charging of those vehicles would be done at off-peak hours. So indeed, when we are not using our capacity, for example, during the evening, we get a greatly enhanced efficiency by having this available.

Mr. ROHRABACHER. It is a point well taken, Mr. Chairman. However, once the number of cars, electric cars, that are actually in service reach a certain point, that savings or that availability then disappears, and it is only something that can be utilized with a small number, from what I understand—we will ask our next witnesses this, I'm sure—it can only be used for—we're talking about 10 percent of the cars, but once you get to a 50 percent level or something like that, that type of savings in the off hours disappears. Is that the case, or am I mistaken?

Mr. MICHAEL DAVIS. Well, again, I think it has to be looked at on a very utility specific point of view, but it is indeed correct that there is energy available off peak for the foreseeable future for these vehicles.

Mr. ROHRABACHER. That is because in the foreseeable future you don't see a major increase in the number of electric vehicles.

Mr. MICHAEL DAVIS. There is clear competition, both on peak and off peak, as I am sure the electric utilities can say better than I, for that electric energy, and there will be.

Mr. ROHRABACHER. Is there any estimate or "guesstimate" as to, if the number—let's just use 50 percent as a measuring stick—if 50 percent of the automobiles on the road today were powered by electricity, what that would do to the price of electricity in the United States?

Mr. MICHAEL DAVIS. If it could be accommodated off peak, it would not—I would not understand why that would necessarily raise the price of electricity to other consumers.

Mr. ROHRABACHER. Well, that is an answer if it can accommodated at off-peak hours, and there is a question—and we will be getting into that exactly—how many cars can be accommodated in off-

peak hours before that benefit is eliminated by the numbers that are involved.

What about pollution? The generation of electricity necessary for 50 percent of our automobiles that are now run by internal combustion engines—would the pollution that is produced by coal-generated plants or oil-generated plants, would that be more or less than the current pollution that is generated by individual automobiles?

Mr. MICHAEL DAVIS. I think even today that pollution, in terms of problem pollution, is less of a problem than automobiles running on oil. But I would say this, that as the penetration of electric vehicles increases—and that is going to take some time; it is also true that the power-producing plants will be improving in terms of their emissions, so that that—both improvements in both areas have to be looked at.

Mr. ROHRABACHER. Okay. Mr. Davis, thank you very much.

Mr. MICHAEL DAVIS. Thank you.

Mr. TORRICELLI. Mr. Campbell.

Mr. CAMPBELL. In the interests of time, Mr. Chairman, I will have no questions.

Mr. TORRICELLI. Thank you, Mr. Campbell.

Mr. Davis, to conclude, does the Department have a judgment on the electric highways work being done by the Department of Transportation?

Mr. MICHAEL DAVIS. I would have to respond for the record, Mr. Chairman. I don't have any position on that today.

[The material referred to follows:]

INSERT FOR THE RECORD

Electrified Roadway

Question: Does the Department have a position on the electrified highway being proposed by the Department of Transportation?

Answer: The Department of Energy supported the evaluation and early development of the roadway powered electric vehicle concept in the late 1970s and early 1980s. More recently, the work has been funded by state and local governments in California, the Electric Power Research Institute, and private and public utility companies in California.

A test track and test facility are currently being planned for construction on the Playa Vista development site in Southern California (the old Hughes Aircraft site). The track and facility will be used for research and development purposes with extensive testing of full sized vans and buses. The electrified roadway concept is an interesting technology that could enhance the use of electricity for transportation. However, there are a number of problems that must first be thoroughly evaluated before it can be given serious consideration, including:

- o A careful evaluation of the impact of the system on the electric utility load since the power demand for transportation will occur during commuting hours which coincides with present peak utility load periods.

- The uncertainty of possible health effects resulting from extended exposure to electromagnetic radiation. Also, how the electrical fields may affect heart pacemakers, radio communication, etc.

- The overall system efficiency and maintenance costs, especially in areas that are subject to frequent freezing and thawing conditions.

It is our viewpoint that even if the above issues can be resolved, the concept may only be practical in certain geographic areas and would not be beneficial to the public in general. Consequently, the present funding structure from state and local governments and organizations is appropriate.

Mr. TORRICELLI. Mr. Davis, thank you for your testimony.

We have a vote. We will recess again very briefly. While we do so, if the second panel could please come forward: Mr. John Bryson, Executive Vice President/Chief Executive Officer, Southern California Edison Company; Michael Gage, President of the Board of Water and Power Commissioners, City of Los Angeles; Robert Steinke, Vice President, Public Service Electric and Gas, of New Jersey; Ray Geddes, President, Unique Mobility, Englewood, Colorado.

Gentlemen, if you could come forward, please, and set up, we will hear your testimony the moment we return.

[Recess.]

Mr. TORRICELLI. Gentlemen, welcome, and thank you for being with us today as the committee looks at the progress made to date, the value of previous Federal investments in research, and the general prospects for electric-powered automobiles. We appreciate your time and your testimony.

I would like to begin, if we could, with Mr. Bryson, Southern California Edison Company. Your testimony, of course, will be entered in the record in its entirety for those members of the committee who are not here and for publication, but we would welcome you to summarize it in any fashion you might think appropriate.

Mr. Bryson, please proceed.

STATEMENTS OF JOHN E. BRYSON, EXECUTIVE VICE PRESIDENT, SOUTHERN CALIFORNIA EDISON COMPANY, ACCOMPANIED BY ROBERT DIETCH, VICE PRESIDENT FOR ENGINEERING, PLANNING, AND RESEARCH; MICHAEL GAGE, PRESIDENT OF BOARD OF WATER AND POWER COMMISSIONERS, CITY OF LOS ANGELES, CALIFORNIA; ROBERT F. STEINKE, VICE PRESIDENT, BUSINESS UNIT DEVELOPMENT, PUBLIC SERVICE ELECTRIC AND GAS COMPANY, NEWARK, NEW JERSEY; AND RAY A. GEDDES, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, UNIQUE MOBILITY, INC., ENGLEWOOD, COLORADO

Mr. BRYSON. Thank you. We appreciate the opportunity to appear before the committee.

I am John Bryson. I am Executive Vice President of Southern California Edison Company. On October 1, I will become chairman and CEO of the company. And on my right and appearing with me today is Mr. Robert Dietch, who is the Vice President of Southern California Edison for engineering, planning, and research, and the electric vehicle work that our company is engaged in extensively falls under Mr. Dietch's responsibility.

We are appearing today not only on behalf of Southern California Edison Company but also on behalf of the Electric Transportation Coalition. The Coalition is an ad hoc group of utilities, State and local governments, and others who are working to promote the greater use of electricity in the transportation sector. Mr. Robert Steinke, who is on this panel and is with Public Service Electric and Gas, and I have jointly submitted written testimony on behalf of the Coalition and on behalf of the Edison Electric Institute.

During the brief time in which I will make these comments, I plan to address the need for electric vehicles, Southern California

Edison Company's involvement in programs intended to accelerate introduction of the vehicles into the marketplace, existing and proposed decisions by the State of California and various other government bodies that are supportive of expanded use of electric vehicles within this decade and beyond, and, finally, the need for auto maker participation and Federal Government assistance if accelerated commercialization of electric vehicles is to be realized.

Finally, if Mr. Rohrabacher returns, I thought I might answer directly a couple of the questions that he posed briefly, but I will do that if he returns.

Our company is committed to electric vehicle technology because electric vehicles, we think, can make a substantial contribution to providing convenient transportation while substantially reducing air pollution. Studies have shown that in California electric vehicles would be 97 percent cleaner than gasoline vehicles and 85 percent cleaner than any of the other alternate fuel vehicles.

As you know, Southern California has the most severe air quality problems in the Nation. If the development of electric vehicles can be accelerated at this time, we believe they could play a role as a principal alternative to gasoline-powered vehicles in reducing very significant amounts of mobile source emissions in the Los Angeles Basin.

The other considerable benefit of electric vehicles is the contribution they can make towards national security. Recent events in Kuwait are a stark reminder of this country's vulnerability in depending as heavily as we do on oil from the Mideast. Imported oil currently accounts for about 50 percent of U.S. consumption, and the transportation sector is the largest user of oil, consuming more than 60 percent of the oil used in the country.

Electric vehicles offer a response in that they can be powered by diverse and abundant domestic supplies and can assist in reducing our national dependence on imported oil. Nationally, electricity is generated only about 5 percent by oil, and in California the percentage of oil used in electricity generation is even less. So substitution of electricity for oil has substantial benefits in reducing that dependence, and one study has been done, for example, by the Electric Power Research Institute that shows that substitution of electric vehicles for each 1 percent of the 200 million vehicles in the country would save approximately 35 million barrels of oil per year—1 percent reduction, 35 million barrels of oil per year. That would also reduce the trade deficit by at least $1 billion annually.

Another benefit of widespread use of electric vehicles is that they can be charged, as the chairman indicated in the earlier colloquy, from power plants generating electricity off peak, and let me simply say now in response to the question Mr. Rohrabacher put that studies by Southern California Edison and the Los Angeles Department of Water have indicated that in the Los Angeles Basin about one million vehicles could be charged by electricity. That is, you could introduce one million electric vehicles without requiring any additions whatsoever to existing electric generating plant or electric transmission systems. But we are a long ways from that. We would be pleased to move rapidly to numbers less than that, but that would require no additional plant at all, and since it would make use off peak of plant which currently stands idle, it

would enhance the efficiency and productivity of existing plant, which in turn would mean very considerable savings to electric customers in the form of reduced cost per kilowatt hour of usage.

The benefits of electric vehicles are being recognized now in California, in air quality regulatory programs implemented by the South Coast Air Quality Management District, and by the California Air Resources Board, and along with the City of Los Angeles we are a cosponsor of the Los Angeles Initiative, which is an effort on our part to introduce as many as 10,000 electric vehicles into the South Coast Air Basin by 1995. I will leave it to my colleague and friend, Mr. Gage, to describe that Los Angeles Initiative a little further.

Turning to Southern California Edison's initiative on its own behalf, we currently operate 15 electric vehicles in a demonstration program which is designed to familiarize fleet operators with the capabilities of electric vehicles. We view fleet managers as the initial customers of EV's, and we believe that offering them practical experience is important in laying the groundwork for widespread consumer acceptance of this technology.

Development of electricity as a transportation fuel should also be stimulated in California by a requirement that has now been proposed by the California Air Resources Board at the State level to mandate the use of zero emissions vehicles starting in 1998, and, in addition, as you know, this House has passed Clean Air Act amendments currently in conference committee which include a California pilot program that would require the introduction of 150,000 alternate-fueled vehicles in California beginning in the model year 1994 and 300,000 vehicles per year beginning in model year 1997. Under this program, EPA is to issue emissions standards for alternate-fueled vehicles based on the best technology available at the time the vehicles are introduced. EV's can play a significant role in this program if we are able to deal with cost and related issues by the time alternate-fueled vehicles are to be available in California.

I should say that while we, as a company, support these various Government mandates that I have described which encourage the use of alternate fuels, the marketplace must ultimately accept these vehicles if we are to reach our shared goal of a better environment and greater energy security. To that end, the Coalition believes it is important that incentives, incentives in addition to mandates, be provided both for the timely development as well as the ultimate customer acceptance of electric vehicles.

One such incentive would be enactment and funding of the Brown legislation pending in this subcommittee. We strongly support this legislation. We believe H.R. 3852 would encourage the production of electric vehicles and could ensure the purchase and use of thousands of vehicles in cities suffering from poor air quality. Importantly, the legislation contemplates cost sharing with industry so that the commitment of all parties is evidenced, and, finally, the Government's financial support is limited to the difference between the expected higher price of the electric vehicle compared to the cost of a comparable gasoline-powered vehicle. Once higher volume production is achieved, economies of scale should dramatically reduce vehicle cost and ensure the lessening of direct Government involvement.

I want to note that current technology utilizing the time-tested lead acid battery is available and is acceptable as a reliable technology for introduction into the marketplace during the early 1990's. We should therefore, we believe, not fail to move forward now. A window of opportunity will exist during the 1990's as Government bodies responsible for air quality impose progressively more stringent standards on tail pipe emissions. If electric vehicles are not made a viable option during this period, the principal opportunity for this environmentally superior mode of transportation may well be missed.

Finally, I would like to briefly describe our cooperation with the major automobile manufacturers in pursuing the development of electric vehicles. Southern California Edison will be working with the Chrysler Corporation to support the introduction of the TEVan, the next generation electric vehicle utilizing a minivan chassis and incorporating an advanced battery technology. Ford Motor Company has offered several dozen prototype vehicles to California utilities as well as to utilities in other nonattainment regions of the country for field evaluation in the 1992/1993 time frame. Up to 50 vehicles will be made available through this program, and Edison expects to obtain as many as 10 of those. And then, finally, through its Truck and Bus Division, General Motors has agreed to distribute, market, and sell electric G-Vans to be produced by smaller manufacturers. General Motors has also invited our participation in a multi-year electric vehicle development effort, and we expect to acquire prototype vehicles through this effort.

In response to the need for improved battery performance, it is our understanding that several of the major auto makers have recently discussed a cooperative program among the manufacturers, the utility industry, and the Government to accelerate development and availability of advanced batteries in production volumes by the mid-1990's. Edison is fully supportive of this type of joint effort and is prepared to participate. We encourage the Federal Government to join in that effort as well.

In conclusion, Mr. Chairman, we strongly endorse favorable and quick action on H.R. 3852, and we are very much encouraged by your interest in electric vehicles. Our Nation needs the environmental and energy security benefits that can be provided. Mr. Dietch and I would be pleased to answer any questions you may have.

[The prepared statement of Mr. Bryson follows:]

STATEMENT OF THE ELECTRIC TRANSPORTATION COALITION

AND THE EDISON ELECTRIC INSTITUTE

before the

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

September 25, 1990

This statement is submitted on behalf of the Electric Transportation Coalition, an ad hoc group of utilities, state and local governments and others interested in increasing the use of electricity in the transportation sector, and the Edison Electric Institute. (A Coalition membership list is included as Attachment 1 to this statement.)

The Electric Transportation Coalition strongly supports the provisions of H.R. 3852, the Electric Vehicle Technology Development and Demonstration Act of 1990, that will encourage the wider use of electric vehicles in the transportation sector.

Energy Security And Economic Benefits Of Widespread Electric Vehicle Use

While the development of alternatives to gasoline is necessary to address environmental issues, another important public policy factor to be considered in designing programs to encourage the use of alternative fuels is the impact that fuel choice has on our national energy security. Never has this impact been more visible than today, given the current situation in the Middle East.

As U.S. demand for oil has increased, so has our national dependence on imported oil. Imported oil has provided nearly 50 percent of total U.S. consumption in recent months. Since the transportation sector is the largest user of oil -- consuming more than 60 percent of the oil used in this country -- the use of alternatives to gasoline is perhaps the single most effective means to reduce our dangerous reliance on insecure supplies of foreign oil.

In addition, the financial impact of our reliance on foreign imports is substantial. Before the Iraqi invasion of Kuwait, oil imports accounted for about one-quarter of our balance of trade deficit. And the Persian Gulf crisis has resulted in increasing oil prices with associated widespread ramifications on our overall national economy. Sound measures designed specifically to decrease U.S. reliance on imported oil are needed.

EVs could provide significant economic and energy security benefits, not the least of which is that electricity has the advantage of being generated from a broad mix of secure domestic resources. Replacement of gasoline-powered vehicles with electric vehicles could displace large amounts of imported oil. According to the Electric Power Research Institute (EPRI), substitution of electric vehicles for each one percent of the 200 million vehicles currently registered in this country would save approximately 35 million barrels of oil per year. This level of replacement by EVs would also reduce our trade deficit by at least $1 billion annually (based on the price of oil before recent increases resulting from the Persian Gulf crisis).

Environmental Benefits Of Electric Vehicles

Concerns about urban air pollution and the impacts of energy choices on our global climate also have prompted a critical look at the U.S. transportation system. Emissions from roadway vehicles have been identified as a primary cause of non-attainment of air quality standards for ozone and carbon monoxide. While many advances have been made in reducing emissions from internal combustion engine vehicles, it is clear that other approaches also must be developed to further reduce mobile source pollution. Vehicle miles travelled are on the increase, producing increased emissions along with the associated problems of traffic congestion, wear and tear on the roadways and noise pollution.

A. Benefits from Reduced Vehicle Emissions

Many states and localities are becoming active in efforts to encourage use of alternatively fueled vehicles as a means of improving air quality. The State of California has been a leader in these areas, and is the source of much of the existing statistical data that can be used to estimate the impacts of electric vehicles on air quality. For example, the California Air Resources Board (CARB) has published emission rates for several alternative fuels. The CARB results factor in the incremental emissions attributable to generating the electricity required to recharge the electric vehicles. The results demonstrate that of the alternatives to gasoline powered vehicles, EVs not only offer the greatest reduction in emissions when compared to gasoline vehicles, but are virtually emission free during operation. (See Attachments 2 and 3.) In fact, EPRI estimates that replacement of just one percent of the vehicles registered in the U.S. today with electric vehicles would reduce emissions by 160,0000 tons per year from what they would otherwise be.

B. Reduction of Greenhouse Gases

With respect to emissions of greenhouse gases, EVs also show significant benefits. In California, for example, generating electricity needed to recharge EV batteries would produce 60 percent less CO2 than would the continued use of gasoline-powered vehicles. (See Attachment 4.) The impact on CO2 emissions produced by increased EV use would be especially significant if the electricity used to recharge vehicle batteries is produced from renewable sources or nuclear power.

C. Energy Conservation and Efficiency Benefits

The Persian Gulf crisis has also renewed public interest in energy efficiency and the conservation of existing supplies. EVs are far more efficient in use of power than gasoline-powered ICE vehicles. A full sized electric van is expected to be 25 percent more efficient in fuel consumption than a similarly sized gasoline-powered van. The improvement is even more dramatic when minivans are compared: an electric minivan is estimated to be 40 percent more efficient than a similar gasoline-powered vehicle. (See Attachment 4.)

National Energy Policy Should Address The Need To Overcome Market-Based Barriers To The Commercial-Scale Production Of Electric Vehicles

The reality of sharply increased gasoline prices, coupled with recurrent instability in the Middle East, dramatizes the need to move away from near total reliance on gasoline as a transportation fuel. Those alternately fueled vehicles that best meet consumer preferences and are most able to cost-effectively comply with new public policy dictates will have the best chance

of market acceptance. However, the advantages of EVs described above -- their contribution to a cleaner environment and greater national and economic security derived from greater energy security -- currently relate more to "general public benefits" than to benefits likely to be realized by individual consumers of electric vehicles. Unless or until consumers are convinced that the product meets their individual needs (with respect to reliability, cost and convenience), or until public policy dictates a change in consumer habits, EVs, despite their public benefits, are not likely to displace conventionally-fueled vehicles.

Despite years of technology development efforts that concentrated substantial public and private resources on vehicle design and battery research, electric vehicles for highway use are not commercially available today. A number of barriers that prevent this technology from reaching its full potential have been identified. While some are technical, the most difficult obstacles to overcome are market-based. Congress can take the initiative now, through H.R. 3852 and other appropriate legislation, to advance the prospects for electric vehicles.

Market-Based Barriers To Electric Vehicles

Today's convergence of energy and environmental issues creates an important opportunity for electric vehicles. The most logical introductory niche markets for EVs are in vehicle fleets and in those urban areas of the country where attainment of air quality standards is most difficult, where the environmental benefits of EVs would have the greatest impact, and where the operational limits of current EVs are acceptable.

However, there is no market-driven demand for electric vehicles currently. Factors that hamper the development of an EV market are high initial vehicle cost and potential purchasers' inability to evaluate EV performance in actual driving conditions. Also, certain infrastructure issues remain to be resolved if an EV marketplace is to be developed. These market-based impediments are more fully described below.

- High purchase price: To date, potential EV manufacturers and fabricators have been unwilling to make the investments necessary in facilities for the high-volume production of electric vehicles without stronger indications of consumer demand for EVs. As a result, only a relatively small number of proof of concept or prototype vehicles have been made available in this country. The lack of production facilities has kept the per vehicle cost high compared to comparable gasoline-powered vehicles. Without volume production, which is expected to achieve significant economies of scale and thereby lower costs, consumers will resist paying the high purchase price per vehicle.

- Lack of experience with EV performance: Without volume production, consumers are unable to evaluate the performance of EVs in actual on-the-road-use, and are unwilling to commit to the use of a large number of EVs until they are satisfied that EV performance characteristics are acceptable.

- Infrastructure issues: Supporting the introduction of a new vehicle technology will require a number of consumer service-oriented steps. Creation of an initial distribution network is required, and must be carefully planned to assure that EVs are available in those areas of the country where they can make the largest contribution to attaining air quality standards. Although EV maintenance costs are expected to be less than those of conventional vehicles, service networks still will need to be established. Also,

provisions for recharging need to be developed, in conjunction with the electric utility industry.

- Need for major industrial support: Successful development of a domestic EV manufacturing capability will require the active involvement of major automotive manufacturers that possess the ability to offer system engineering and safety and reliability testing. Some of the smaller entities that have traditionally been at the forefront of EV development efforts have not had the capability to provide these services. Today there is increasing involvement in the electric vehicle development program by General Motors, Chrysler and Ford and other major manufacturers. GM's announcement that it has designed a prototype two passenger EV has generated considerable excitement. GM participated in the development of the electric G-Van along with EPRI, and has announced plans to distribute the G-Van through its truck and bus division in southern California. Chrysler is actively involved in the development of the next generation electric van, the TEVan. Ford expects to offer several dozen EV prototypes to utilities in nonattainment areas in the 1992-1993 timeframe. The fact remains, however, that no major automaker has yet announced plans to commercially produce EVs.

Technical Challenges Facing Electric Vehicles

Much of the unrealized promise of the electric vehicle may be attributed to the continuing need for technical improvements with batteries as energy storage devices, and within other components of an EV such as electrical drive trains. Nevertheless, public policymakers at all levels must recognize that proven EV technology is available, and that millions of miles have been driven in electric vehicles all over the world.

An important task facing us now, in addition to the need for continuing technical improvements, is to get the available technology on the road -- to build a performance history that will convince consumers and manufacturers alike of the benefits of EVs and to identify areas where technological improvements would have the most impact.

- Technical limitations on vehicle range: The electric vehicles closest to the point of commercialization today are powered by conventional lead-acid batteries. While the lead-acid battery configuration has been shown to be highly reliable, the battery pack must be periodically replaced during the life of the EV, which significantly affects the life cycle cost of the vehicle. With the lead-acid technology, a full sized electric van (the Electric G-Van) has been designed, is in prototype production, and has received Federal Motor Vehicle Safety Standards (FMVSS) certification. Current EVs powered by lead-acid batteries are capable of a 60 mile range between recharging, which is suitable for many urban fleet applications. In fact, as many as 40 percent of commercial light duty fleet vehicles in major urban areas travel only 60 miles in any given work day. Nevertheless, the existing limitations on vehicle range make it essential that an initial niche market -- urban fleets -- be developed for the introduction of EVs, and that improvements in vehicle range be achieved before EV technology will be acceptable to a broad spectrum of consumers.

- Other performance concerns arising from the need for improved battery technologies: Improvements in battery technology resulting in improvements in vehicle performance are essential to the ultimate commercial acceptance of

electric vehicles. Increased investment in battery R&D is therefore required. Yet investment in battery research is effectively stymied today by the lack of a major outlet for battery products resulting from the uncertain commercial prospects for electric vehicles. By developing an EV market, a market for improved EV battery products would also be created.

- Further technical advances: Improvements in power electronics, concentrating on improved power trains will add to the reliability of the electric vehicle and improve its efficiency, reduce its weight and increase its range. The use of alternate power units (APUs) to recharge batteries during vehicle operation could also significantly extend the vehicle range per charge.

A Federal Electric Vehicle Commercialization Program Is Necessary

The type of initiative needed to address the problems of EV commercialization has a parallel in the automotive industry: "seeding" the market with a new product. Through "seeding," the market is shown the product, enabling consumers to become familiar with it and leading to improvements in the product.

For electric vehicles, a multi-year, federally funded production incentive program like that proposed in H.R. 3852 is required. Such a program would send a clear signal to the marketplace -- EV producers and potential consumers -- that this nation recognizes electric vehicle technology development and demonstration as a key element of energy and environmental policy. The magnitude of the benefits offered make it appropriate to devote public funds -- properly leveraged by substantial private commitment -- to an electric vehicle commercialization program.

The production incentive program of H.R. 3852 has a number of key provisions, including:

- A requirement for vehicle purchase cost sharing between private and public sector participants, with limitations on the percentage of the per vehicle cost that may be paid by federal funds;

- A limitation on federal support to that period in which it is most essential -- the early years of introduction of a new product;

- A program targeted to those non-attainment areas with the most significant need for air quality improvement, (which must also emphasize the need for geographic diversity to assure a nationwide program);

- A program directed to potential manufacturers, to develop a continuing manufacturing capability and to address directly the problem of high initial electric vehicle cost;

- Administration of the program through the Department of Energy, building on its established expertise, with appropriate consultation with the Departments of Transportation and Commerce and the EPA;

- A multi-year program duration, to provide stability in the program and to permit the integration of advanced battery technologies and other technology improvements; and

- An ultimate goal of driving down the cost of EVs, calculated on a life cycle basis, to be on a parity with the life cycle costs of a comparable conventionally fueled vehicle.

Other Developments Which May Impact On The Prospects For Electric Vehicles

Developments in connection with other legislation pending before Congress could also have implications for EV commercialization. The Coalition is closely monitoring developments in several areas.

Energy Policy Legislation

The Senate has passed S. 324, legislation to establish a national energy policy to deal with global climate change issues. A companion bill, H.R. 5521, has been introduced in the House. In addition to incorporating the provisions of H.R. 3852, these measures authorize a three year, $30 million program of research, development and demonstration of electric vehicle and battery technology. This program would require 50/50 cost sharing through public-private joint ventures. This partnership will leverage and extend federal financial resources directed to resolving technical issues of EV and hybrid vehicle design and propulsion systems.

Improvements in these areas, as discussed above, will greatly enhance the prospects for ultimate commercial acceptance of electric vehicles. The Coalition supports this proposed RD&D program, and urges that appropriate electric vehicle incentives be included in any energy policy measure adopted this year.

Clean Air Act

By requiring the production and sale of alternatively fueled vehicles in California beginning in the mid-1990's, the California Pilot Program included as part of the House-passed version of the Clean Air Act legislation, H.R. 3030 promises to exert substantial pressure to make widespread alternative vehicle use a near-term reality.

As passed by the House, the California Pilot Program would require meaningful emissions reductions for passenger vehicles. Electric vehicles are capable of meeting both the Phase I (50 percent reduction in emissions of volatile organic compounds (VOC) from the baseline standard emissions level of a conventionally fueled vehicle) and Phase II (75 percent reduction in VOC emissions) standards. Indeed, depending upon the nature of the baseline standard selected, electric vehicles may be the only vehicle capable of attaining the Phase II standard.

Both the House and Senate clean air legislation contain provisions regarding the use of alternatively fueled vehicles in fleets. Free-standing legislation, S. 1058 and H.R. 2175, would also encourage the use of alternatively fueled vehicles in federal government fleets. Such provisions could assist in the development of initial niche markets for electric vehicles.

CAFE Program

Another outgrowth of the situation in the Middle East is the additional focus on the corporate average fuel economy (CAFE) program. Legislation, S. 1224, calling for phased-in increases in CAFE standards to reach 40 miles per gallon by 2001 was reported by the Senate Commerce Committee in June 1990 and is pending on the Senate floor. A companion proposal, H.R. 5560, was recently introduced in the House. In addition to cutting the use of oil, the CAFE program has also been seen as a means of encouraging the use of alternatively fueled vehicles. In 1988, as part of the Alternative Motor Fuels Act, Congress provided for the creation of credits to manufacturers to be applied to their CAFE requirements for the production of vehicles capable of operating on methanol or natural gas. EPA is in the process of

establishing the calculations to be used in determining the credits to be given for these vehicles, with the credits to take effect in 1993. A CAFE credit program for electric vehicles has been on the books since 1980. However, the means of calculating the EV credit expired in model year 1987. The Department of Energy is responsible for updating the calculation method.

If the Congress decides to amend the CAFE standards, then it is suggested that CAFE credits for electric vehicles be meaningfully enhanced so as to provide an incentive for EV production.

Defense Authorization Legislation

The Senate-passed version of the defense authorization legislation, S. 2884, included an amendment to establish a national oil import ceiling of 50 percent of United States consumption and require the development of an emergency national energy security plan. Under the Senate-passed amendment, the President would be required to make projections of oil import levels and advise Congress of actions to be taken to avoid exceeding the ceiling. If the ceiling is exceeded for a period of six months within any twelve month period, the President would be required to submit to Congress and implement an Energy Production and Security Action Plan including specific actions to reduce imports.

The amendment specifies that the Action Plan must include "energy conservation actions including improved fuel efficiency for automobiles and the development and utilization of alternative transportation fuels." If similar provisions are adopted during House consideration of the defense authorization or other legislation, the Coalition recommends retaining the emphasis on alternative fuels included in the Senate-passed provision and strengthening it where possible.

Tax Incentives

Legislation already pending before Congress, H.R. 2269, introduced by Representative Andrews, would provide an investment tax credit for vehicles powered by clean-burning fuels. Because of the way in which this legislation is drafted, however, the incentive it would provide for converting vehicles powered by gasoline to run on clean burning fuels would not be available to manufacturers of electric vehicles.

Specifically, "clean-burning fuels" are defined in H.R. 2269 as natural gas, liquefied petroleum gas and methanol, ethanol or other alcohol fuels. Electricity is not included in the enumeration of clean-burning fuels, and for this reason electric vehicle producers would presumably not qualify for the new tax credit the measure proposes.

In any tax proposal designed to encourage the use of alternative fuels, at a minimum electricity must be included in the definition of "clean burning" or "clean alternative" fuels. Consideration should also be given to creation of an investment tax credit or other tax incentives designed specifically to encourage EV production. Such a credit could be designed around the following principles:

* An investment tax credit for manufacturers of electric vehicles, to encourage investment needed in production facilities, to increase production levels and reduce the high manufacturing cost of electric vehicles at low volume production.

* Alternatively, or in addition, a credit could be given to manufacturers for actual EV sales. To increase the environmental benefit of such an incentive, the credit could be

restricted to sales of vehicles to be used in designated areas that have been unable to attain federal air quality standards due to mobile source pollution.

- Either tax credit could be transferrable, to encourage the formation of inter-industry relationships necessary for the creation of a production capability and a sustained EV market.

- The tax credit's duration could be limited to ten years to reflect the increasing pressure for environmentally acceptable vehicles that will occur during the decade of the 1990's.

Another series of tax incentives which should be investigated would be those directed to ultimate vehicle purchasers. For example, a business investment tax credit could be offered for investment in electric vehicles to replace conventionally-fueled fleet vehicles. A credit could also be provided for individual buyers, as an incentive to encourage EV penetration into the consumer vehicle market.

Any of these incentives would, we believe, offer meaningful help to many entities interested in the establishment of a electric vehicle marketplace and offer assistance in overcoming the significant cost disparity that will exist between EVs and gasoline-powered (and other clean-fueled) vehicles in the early years of EV commercialization.

Conclusion

Electric vehicles can provide convenient transportation in an environmentally acceptable manner. The emissions reductions that can be achieved by substituting electric vehicles for conventionally-fueled vehicles are significant. Electric vehicles have the associated benefit of offering an important means to reduce our growing national dependence on unstable supplies of imported petroleum.

Action at the federal government level is necessary to assure that the benefits of electric vehicles are realized in the near term. High per vehicle costs, as well as lack of actual on-the-road driving experience, have kept the demand for electric vehicles far below the level necessary to justify manufacturers' investment in production facilities. Without carefully designed incentives, it is likely that EVs will continue to be produced in only very small numbers at prohibitive costs.

Congress has an important opportunity to act now. The federal government can and should assume a leadership role in encouraging electric vehicle production and technology advancement to assure that the environmental and energy security benefits of EVs will be achieved. The Electric Transportation Coalition urges that this principle be reflected in the favorable consideration of H.R. 3852 and other alternative fuels related proposals in this session of Congress.

Attachments

ATTACHMENT 1

ELECTRIC TRANSPORTATION COALITION
MEMBERSHIP LIST

September 11, 1990

American Public Power Association
City of Chicago Department of Planning
City of San Diego
Edison Electric Institute
Florida Solar Energy Center
GPU Service Corporation
Los Angeles Department of Water & Power
National Rural Electric Cooperative Association
New York City Department of Telecommunications & Energy
Pacific Gas & Electric Company
Public Service Electric & Gas Company
Sacramento Municipal Utility District
Southern California Edison
State of Colorado
The Doe Run Company

Air Quality Improvement Potential of Alternate Clean Fuel Vehicles

% Emissions Reduction Compared to Gasoline

Alternate Clean Fuel Vehicle (Passenger)	Reactive HC		*CO*	*NOX*
	Total	*Exhaust*		
Electric	98% less	98% less	99% less	89% less
CNG	51% less	46% less	93% less	33% less
LPG	48% less	43 % less	Same	59 % less
Methanol	13% less	29% less	29% less	32% less

Source: California Air Resources Board, Mobile Source Division, Definition of a Low-Emission Motor Vehicle in Compliance with the Mandates of Health and Safety Code Section 39037.05, May 1989.

ATTACHMENT 2

California Air Resources Board
1989 Emission Comparison
Tons/Year Emission Results
1989 California Air Resources Board Report

Single Vehicle at 20,000 miles/year	Total Reactive HC (Pounds)	CO (Pounds)	NOx (Pounds)	Total Pollutants (Pounds)
Gasoline Powered	17.181	61.674	29.075	107.93
Electric	.264	.352	3.084	3.70

1000 Vehicle Fleet at 15,000 miles/year	Total Reactive HC (Tons)	CO (Tons)	NOx (Tons)	Total Pollutants (Tons)
Gasoline Powered	6.443	23.130	10.905	40.478
Electric	.099	.132	1.157	1.388
Total Pollutants Reduced	6.344	22.99	9.74	39.09
Percent Reduced	99%	99%	89%	97%

Source: California Air Resources Board, Mobile Source Division, Definition of a Low-Emission Motor Vehicle In Compliance with the Mandates of Health and Safety Code Section 39037.05, May 1989.

ATTACHMENT 3

EPRI Leadership in Science and Technology

Technical Brief

CUSTOMER SYSTEMS DIVISION

Electric Van and Gasoline Van Emissions: A Comparison

For many years, EPRI has been working with major automotive manufacturers to develop reliable, practical electric vehicles (EVs) that meet industry and consumer standards. This effort has produced two electric vans, the Electric G-Van and the TEVan minivan, that are slated for use in commercial service fleets within the next few years. As a first step toward determining the potential environmental benefits and impacts of EVs, EPRI has compared the emission characteristics of these near-term electric vans with their gasoline-powered counterparts, classifying emissions from three environmental perspectives: urban air quality, global warming, and acid rain.

Table 1
Vehicle Characteristics

	GM Gasoline-Powered Van	Electric G-Van	Chrysler Gasoline-Powered Minivan	Electric TEVan
Wheelbase	125 in	125 in	112 in	112 in
Gross vehicle weight	8600 lbs	8600 lbs	3975 lbs	5548 lbs
Cargo volume	256 cu ft	256 cu ft	133 cu ft	133 cu ft
Range	—	60 miles†	—	120 miles*
Top speed	—	52 mph†	—	65 mph*

†Simulated urban driving
*Projected

Table 2
Energy Efficiencies of Gasoline and Electric Vans

	GM Gasoline-Powered Van	Electric G-Van	Chrysler Gasoline-Powered Minivan	Electric TEVan
Fuel efficiency	10 mi/gal	1 mi/kWh	18 mi/gal	2 mi/kWh
Energy consumption	14,400 Btu/mi	10,800 Btu/mi	9000 Btu/mi	5400 Btu/mi

Vehicle Characteristics

Table 1 shows technical specifications for each of the vehicles in this comparison. The GM gasoline-powered van is compared to the Electric G-Van because they have similar load-carrying characteristics. Likewise, the Chrysler minivan is compared to the Electric TEVan.

Sources of Emissions

Gasoline Vehicles: For gasoline vehicles, the emission figures shown include both tailpipe emissions and the emissions associated with refinery operations and fuel distribution.

Electric Vehicles: Electric vehicles do not emit any pollutants during operation. All emissions associated with EVs come from the power plants that provide electricity to the vehicles and are totally dependent on the generation mix used.

Different types of power plants display very different emission characteristics. Future power plants will be considerably cleaner than the fossil-fueled power plants that are operating today. For this study, EV emissions from different present and future generation scenarios are provided to bracket the range of possibilities.

In all generation scenarios, EV emissions shown here take into account all direct and indirect emissions associated with electrical energy production, including those from mining operations, fuel transportation, energy conversion, and electricity transmission and distribution.

Energy Efficiency

The energy efficiencies of gasoline and electric vans are shown in Table 2. Both types of vans are assumed to be operating in an urban environment and functioning as fleet vehicles. For electric vans, the energy consumption (Btu/mile) includes the losses from mining, energy conversion, and the transmission of electrical energy.

Urban Air Quality

The principal emissions that contribute to urban air quality problems are volatile organic compounds (VOCs) and nitrogen oxides (NO_x)—both precursors of ozone—and carbon monoxide (CO). Tables 3 and 3A compare gasoline-powered van emissions based on current California and U.S. 1989 emission standards with EV emissions under different generation scenarios.

Global Warming

Tables 4 and 4A compare emissions of carbon dioxide (CO_2)—the principal emission linked with global warming—for gasoline- and electric-powered vans.

Table 3
Fleet Van Emissions Associated with Urban Air Quality
(grams per mile)

	GM Gasoline-Powered Van		Electric G-Van		
	Current Emissions		Generation Scenarios		
	California	U.S.	LA Basin Current	U.S. Current	U.S. New Post-1995
VOCs	0.8	1.1	0.02	0.02	0.02
NO_x	1.1	1.8	0.17	2.5	0.7
CO	9.0	10.0	0.02	0.1	0.1

Table 3A
Fleet Minivan Emissions Associated with Urban Air Quality
(grams per mile)

	Chrysler Gasoline-Powered Minivan		Electric TEVan		
	Current Emissions		Generation Scenarios		
	California	U.S.	LA Basin Current	U.S. Current	U.S. New Post-1995
VOCs	0.7	1.0	0.01	0.01	0.01
NO_x	1.1	1.8	0.08	1.2	0.3
CO	9.0	10.0	0.01	0.05	0.05

Table 4
Fleet Van Emissions Associated with Global Warming
(grams per mile)

	GM Gasoline-Powered Van	Electric G-Van				
	Current Emissions	Generation Scenarios				
	U.S. Average	Calif. + Import Current	U.S. Current	U.S. New Post-1995	Coal Plant Current	New Coal Plant Post-1995
CO_2	1100	390	630	640	1090	1030

Table 4A
Fleet Minivan Emissions Associated with Global Warming
(grams per mile)

	Chrysler Gasoline-Powered Minivan	Electric TEVan				
	Current Emissions	Generation Scenarios				
	U.S. Average	Calif. + Import Current	U.S. Current	U.S. New Post-1995	Coal Plant Current	New Coal Plant Post-1995
CO_2	690	195	315	320	545	515

Acid Rain

The release of SO_2 and NO_x into the atmosphere from power plant stacks has been identified as a primary cause of acid rain. Under President Bush's proposal to control acid rain, many existing and new power plants will be required to use SO_2 and NO_x reduction technologies. By the year 2000, use of such technologies could decrease annual power plant SO_2 and NO_x emissions by 9 million tons and 2 million tons, respectively. Implementing emission reduction strategies would increase the cost of electricity in some regions of the United States. However, this increase is not expected to affect the economic viability of EVs. Tables 5 and 5A compare SO_2 and NO_x emissions from gasoline- and electric-powered vans.

Conclusions

This comparison of the emission characteristics of gasoline- and electric-powered vans suggests that EV use could help mitigate two serious environmental problems: urban air pollution and global warming. Widespread EV use could contribute (albeit minimally) to increased power plant emissions of SO_2 and NO_x. However, use of emission reduction technology could help control these emissions with only minor increases in EV operating costs.

For further information on emissions from gasoline- and electric-powered vans, call EPRI Project Manager Tim Yau, (415) 855-2559. For additional information on electric vans, contact the EPRI Transportation Program Office, (415) 855-2981.

Table 5
Fleet Van Emissions Associated with Acid Rain
(grams per mile)

	GM Gasoline-Powered Van		Electric G-Van				
	Current Emissions		Generation Scenarios				
	California	U.S.	Calif. + Imports Current	U.S. Current	U.S. New Post-1995	Coal Plant Current	New Coal Plant Post-1995
SO_2	0.2	0.2	0.7	8.0	1.0	10.0	2.0
NO_x	1.1	1.8	0.8	2.5	0.7	3.6	1.0

Table 5A
Fleet Minivan Emissions Associated with Acid Rain
(grams per mile)

	Chrysler Gasoline-Powered Minivan		Electric TEVan				
	Current Emissions		Generation Scenarios				
	California	U.S.	Calif. + Imports Current	U.S. Current	U.S. New Post-1995	Coal Plant Current	New Coal Plant Post-1995
SO_2	0.2	0.2	0.3	3.0	0.5	5.0	1.0
NO_x	1.1	1.8	0.4	1.2	0.3	1.8	0.5

Assumptions and Sources

Energy efficiency

Gasoline vans: General Motors, Chrysler Corporation

Electric vans: Electric Power Research Institute

Generation scenarios

Los Angeles Basin: Southern California Edison Company, Theodore Barry & Associates

California: California Energy Commission

United States: North American Electric Reliability Council

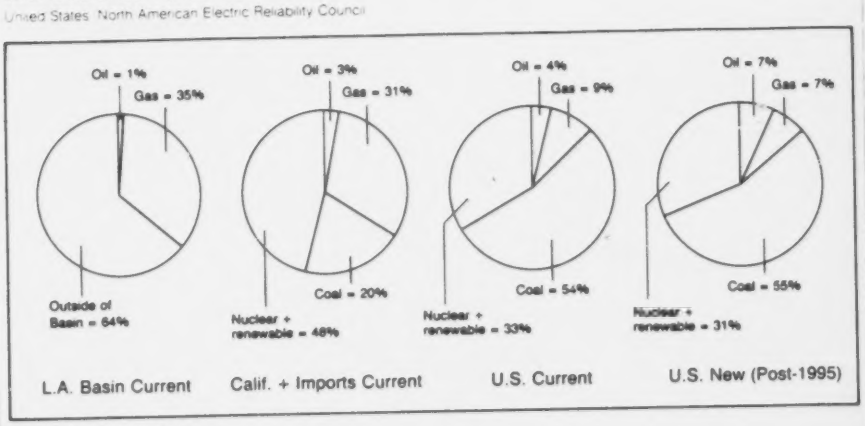

Figure 1. Generation scenarios.

Power plant emission characteristics

Power plants in L.A. Basin: Southern California Edison Company, Theodore Barry & Associates, Electric Power Research Institute

Power plants in the United States: Electric Power Research Institute, Environmental Protection Agency

Gasoline van emission characteristics

California: California Air Resources Board, California Energy Commission

United States: Environmental Protection Agency, Electric Power Research Institute

Emission characteristics of power plant plants in the United States (grams/kWh)

Plant Type	VOCs	CO	NO_x	SO_2	CO_2
Gas**	0.025	0.20	2.32 1.00*	0.004	490
Oil**	0.05	0.19	2.02 1.00*	5.08	781
Coal	0.01	0.11	3.54 1.00*	9.26 2.0*	1090 1030*

*Post-1995

**Assumes a mix of 10% combustion turbines and 90% steam turbines.

EPRI
Electric Power Research Institute
Post Office Box 10412, Palo Alto, California 94303 (415) 855-2000

Electric Transportation
Acidic Deposition
Global Climate
Air Quality—Human Health

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Mr. TORRICELLI. Thank you, Mr. Bryson, very much.

The commitment of your company and the important beginnings that it has made are not only impressive, they obviously are a national model, and the company is genuinely to be commended.

Mr. BRYSON. Thank you.

Mr. TORRICELLI. Thank you. I thank you for your testimony.

If we could next, recognizing that a vote is in progress, perhaps we could at least begin with your testimony at this point, Mr. Geddes—I guess not Mr. Geddes; we will get to you last. Let's go in order. Mr. Gage, if you would like at this point to begin, and we'll see how far we get before the buzzers go off again.

Mr. GAGE. Thank you, Mr. Chairman, distinguished Members.

I am testifying today as the President of the Board of Water and Power, Commissioners of the City of Los Angeles, and I appreciate the opportunity to be here before you. I'd like to particularly thank Congressman Brown for his efforts with this measure, H.R. 3852, and I would like to thank you, Mr. Chairman, for featuring it here today before us and giving us an opportunity to discuss the importance of this measure.

I would like to outline for you briefly the L.A. Electric Vehicle Initiative, which is the source of much of the interest in electric vehicles these days. It was introduced by Councilman Marvin Braude with the strong support of Mayor Tom Bradley, passed in 1988. The Department of Water and Power was made the point agency in 1989. Subsequent to that time, we have circulated 200 requests for proposals to businesses throughout the world, but we had 19 substantive responses. They were reduced over time to seven semifinalists. Those semifinalists were then reviewed by the South Coast Air Quality District, the Department of Water and Power, and Southern California Edison, to arrive at two finalists that will produce by 1995 10,000 electric vehicles for consumption in the South Coast Air Basin. We are very actively looking forward to that. We believe we will have prototypes by the end of this year and see full production in 1991. We believe that 10,000 electric vehicles will, in fact, be produced by 1995, and we are certainly going to dedicate our every effort to that event.

I would say that, as someone who has served in State level government and politics and local level, this is a genuine public/private cooperative effort with Southern California Edison and L.A. Department of Water and Power working together. We look to the Federal Government to work with us as well as the State government in providing incentives to bridge the gap, if you will, between the marketability of these vehicles today and the marketability of them to reach that nexus where they are, in fact—do, in fact, stand on their own, which we believe will be in the very near future.

The combination of factors of unhealthy oil dependence on foreign oil and very unhealthy air basins throughout the Nation, 80 of which are nonattainment basins, certainly the City of Los Angeles serves as the first and foremost—or the L.A. Basin—the first and foremost air basin that seems to have the most intractable problems, I would say, looked to us to serve as a laboratory. We are willing to serve as a laboratory. That is what the L.A. Initiative is all about. We would like to work with you so that those experiences learned in the Los Angeles Basin may help the other 80 non-

attainment areas throughout the Nation come into compliance much more quickly than they would otherwise.

Sixty—over 60 percent of the emissions in the L.A. Basin are from automobiles. Over 50 percent of the hydrocarbons are from automobiles. Clearly, electric vehicles, as indicated by John Bryson, are, in fact, 97 percent cleaner than traditional vehicles, and they will make a dramatic statement in the Los Angeles Basin.

Ten thousand vehicles will not begin to meet the need, but we hope the 10,000 vehicles and the demand for those 10,000 vehicles will create the starting of the marketplace. With your help and with the help of H.R. 3852, we believe we can take gigantic steps forward.

I would just say that local government intends to do much more. The City Council, the City of Los Angeles, already makes $5,000 per vehicle available for any vehicle serving as a van in a van pool. That subsidy would be turned to electric vehicles as well. In addition, they have already adopted in concept that all new construction, both residential and commercial, as well as parking structures will include accessible recharging facilities. We are already providing for discounted parking for electric vehicles. We are looking at providing special access even to our single occupant EV's in HOV lanes. We are providing for all units of city government to accommodate fleet usage, not just the Department of Water and Power. And, finally, we are going to be requiring that electric transport elements be included in all aspects of local planning processes both for general and specific plans and even reviewing conditional use permits. We are not going to sit back and expect the Federal Government to bail us out. We would genuinely ask you to participate with us in a public/private cooperative effort to solve a very serious national problem.

I would be delighted to respond to questions as they become available.

[The prepared statement of Mr. Gage follows:]

STATEMENT OF MICHAEL GAGE
President, Board of Water and Power Commissioners
City of Los Angeles, California
before
the Subcommittee on Transportation, Aviation and Materials
of the
Committee on Science, Space and Technology
U. S. HOUSE OF REPRESENTATIVES
on
H. R. 3852

September 25, 1990

Good afternoon.

Mr. Chairman and Members of the Subcommittee, my name is Mike Gage. I am testifying today as president of the Board of Water and Power Commissioners for the City of Los Angeles and I appreciate the opportunity to participate in this hearing on H. R. 3852, the proposed Electric Vehicle Transportation Development and Demonstration Act of 1990. As you know, this measure has been introduced in Congress by Congressman George Brown on behalf of the City and the Electric Transportation Coalition.

Our country faces enormous, complex and sometimes conflicting public policy challenges in this new decade and in the new century just ahead. Having previously served as a member of the California Legislature and, subsequently, as Deputy Mayor of Los Angeles, I also appreciate the way many of these difficult, complicated problems play out in the arena of intergovernmental relations.

These experiences have also convinced me that there is little that cannot be done if, somewhere along the way, solid old-fashioned leadership is present and exercised. There is

no denying the fact that, as others participating in these proceedings have said here today, we have a unique combination problem in this nation involving (a) air quality and (b) a totally unacceptable reliance on foreign oil. I believe, Mr. Chairman, you and your colleagues who are hosting this session -- as well as sponsoring H. R. 3852 -- are to be commended. By drawing the spotlight of Congressional attention to what is unquestionably the optimal path to be followed in mitigating the impact of the automobile on the environment and lessening our reliance on unstable sources of energy, you are simply displaying that old-fashioned leadership which, when present, makes our system of government function at its very best.

A WORD ABOUT LADWP

An appropriate starting point for me, I believe, is to familiarize the Subcommittee with the Los Angeles Department of Water and Power. This largest of the many units of municipal government in L. A., with a workforce of some 11,000, serves some 4 million customers. It is the largest municipal utility in the United States. The Department has a sometimes fabled but nonetheless remarkable record for ready supply of reliable power and high-quality water, financial soundness, rate restraint and, I am especially pleased to say, innovation. Given these traits, it is perhaps understandable that the Department would also be a lead player in the movement

to advance the commercialization of EV technology.

In fact, before getting into any discussion of how grave our air pollution and inter-connected traffic congestion problems are -- and of course these are so bad that they are monologue staples for Johnny Carson, Jay Leno, Arsenio Hall and others -- I want to tell the Subcommittee about a linchpin effort to boost EV commercialization, one with a decidedly L. A. flavor.

L. A. ELECTRIC VEHICLE INITIATIVE

In 1988, the leading environmentalist on the Los Angeles City Council, the Honorable Marvin L. Braude, authored a remarkable and far-sighted plan to face up to the challenge of the nation's worst and seemingly most intractable air pollution problem.

The Braude design to get a measurable and noticeable number of EVs on the roadways of Los Angeles and Southern California as quickly as possible was, after public hearings, approved by the City Council. Its forthright intent was to establish a public/private consortium to help expedite the shift to electric vehicles in our city. Specifically, the Los Angeles Initiative, as it is popularly known, authorizes City sponsorship of an international competition for private companies to develop, produce and market 10,000 EVs in Southern California -- not by the next generation, but by 1995!

The job of implementing this action plan was given to the L. A. Department of Water and Power (DWP). By January, 1989 the Department had circulated a formal request for

proposals to more than 200 organizations around the world. By May, some eighteen substantive replies had been received. And by June, 1989 that number had been winnowed down to just seven company 'finalists' by a review panel which included representatives from Southern California Edison Company, the South Coast Air Quality Management District and the DWP. During the next two months, finalists and their proposals received intensive scrutiny. By last October, two companies had been selected to produce 10,000 EVs for sale and distribution in Southern California.

At present, the DWP is using a number of prototype electric G-vans in its own fleet. These vans are standard General Motors production vehicles which have been modified through the installation of electric drive trains. They have a maximum speed of 53 miles per hour and a driving range of 60 miles for each electric charge. Presently, the Department is using these vehicles for employee shuttles between facilities, maintenance and service calls and for EV demonstration programs.

L. A. Initiative finalists -- a company named Clean Air Transport (based in Sweden and England) and a company known as Unique Mobility, Inc. (of Englewood, Colorado) -- are at work now responding to the urgent need for quiet, clean passenger car transport.

Clean Air Transport will focus on production of four-passenger cars, quarter-ton 'micro-vans', and 2-door pickups with a 150-mile range. Pioneering use of light-weight fiberglass composites and aerodynamic styling will, it is hoped, materially

enhance efficiency.

Unique Mobility, Inc. expects to use such well-known and popular vans as the Chrysler Voyager and Ford Aerostar as its platform. The company hopes to develop a range extender as a means of reducing battery size and increasing payload.

As Councilman Braude himself has observed:

> "The seven finalists were, in the main, small innovative companies willing to play a role in improving the quality of our environment and bringing about change.
>
> These companies are leaders, not followers. They are small and often underfunded, but not afraid to attack the clean-air challenge head on. They are ready to take a risk to improve air quality."

And because funding is the sine qua non of such trail-blazing efforts, a thought which is clearly implicit in H. R. 3852 and its federal incentives for expediting the commercialization of EV technology, the L. A. Department of Water and Power has committed up to $12 million in funding for the L. A. Initiative over a 3-year period. This amount will, it is anticipated, provide about half the total cost of the development work being done by the two finalists. I understand that Southern California Edison is expected to contribute a similar amount.

And our expectations? Frankly, Councilman Braude, Mayor Bradley, my fellow Commissioners, the City Council and I all hope to see production prototypes of two kinds of electric van and one type of passenger car this year. Full-scale production of these vehicles should be underway in earnest

by late 1991.

Moreover, in addition to producing these prototypes and follow-on vehicles, our finalists are also designing essential marketing and servicing systems for Southern California.

PLAYA VISTA ELECTRIFIED ROADWAY

I also want to add, while we are focusing for the moment on actual undertakings to either make EV technology directly available as transportation or otherwise enhance its acceptance in the marketplace -- where it absolutely must eventually stand on its own by consumer choice -- that the LADWP and Southern California Edison are also involved in a $2 million project to develop one of the world's first electrified roadways. Vehicles traversing this street will be powered not by on-board batteries but by drawing energy from a magnetic field created by electricity in the pavement beneath them. With batteries -- and recharging -- eliminated, it is expected that this technology will accomodate lighter-weight vehicles with theoretically unlimited range. Testing, beginning with two vans and a passenger bus, will begin later this year on a stretch of electrified roadway being built in an L. A. suburb between Santa Monica and the L. A. International Airport.

VOTERS ARE TROUBLED

Mr. Chairman, I have consciously used the major portion of the time alloted to me this afternoon to discuss positive responses in one locality to the twin challenges of clean air and energy self-sufficiency. I have done so despite

the fact that clean air warrants both our concern and action and despite the fact that Operation Desert Shield enjoys both our attention and prayers even as it painfully reminds us of the foolishness involved in relying excessively on energy supplies from unstable regions.

I have chosen to focus on creative, innovative responses developed in one local arena because, in my view, citizens and voters across America are growing deeply unhappy with government which seemingly does not work. I am certain that public recourse to initiatives and referenda limiting the number of terms elected officials may serve has won the attention of all here on Capitol Hill. It certainly has won the attention of elected -- and appointed -- officials in California. I believe such anti-government movements make it clear that the electorate wants results. It is demanding action on such critical questions as air quality and energy independence. Our leadership must deliver creative responses which promise short-term payoffs or the American public appears ready to find new leaders who will deliver new answers to these old problems.

L. A. AMBIENT AIR QUALITY

Yes, we do have a special and serious air quality problem in Los Angeles. Just last year, for example, air in the L. A. Basin exceeded the federal ozone standard on 157 days. The year before, the ozone standard was exceeded on 176 days and, worse still, federal health standards for all ambient air quality were broken on at least two of every three days.

Of course, we are not alone; some 80 metropolitan areas across the nation have similar problems. Yet we are unique, both in terms of the gravity and enormity of our air quality impairment and, remarkably, in our efforts to overcome it. L. A. has long had the strictest controls on air pollution anywhere. In fact, my own Department of Water and Power has managed to reduce air emissions from its in-Basin power generating plants by more than 90% in the last 20 years. Others have made comparable efforts and still, we have been running hard while standing still or even falling behind in our struggle to restore clean air.

The answer involves, of course, both topography and meteorological conditions. There is little any of us can do about these elements in the mix which produces smog. The automobile also figures heavily into the mix producing our pollution. Motor vehicles now contribute about two-thirds of all the pollutants and about 50% of the hydrocarbon emissions in the L. A. Basin. Looking ahead, when demographers tell us there will be at least 5 million more people in our Basin, there will also be about one new automobile on our already-choked freeways for every four there today. Regional authorities estimate that the number of vehicle miles traveled locally by 2010 will increase from about 275 million a day currently to 400 million. Obviously the combination of population and economic growth, of vastly more people operating vastly more vehicles idling in still-greater traffic gridlock poses an ominous -- not a promising -- portent for tomorrow's ambient air quality.

Clearly, it is the automobile and its complex role in our lives and its tremendous impact on our environment which warrants attention. And that, in the end, is what all of our local efforts in L. A. -- including the L. A. Initiative and the electrified roadway -- are about: finding a 'fix' for the automobile's undeniably negative impact on our environment.

And, of course, that is what this hearing and H. R. 3852 are also all about. Getting from today to a day when the roadways of Southern California -- and the nation -- are populated by at least a ten- or twenty-percent share of EVs which are quiet and virtually non-polluting will require not just technological innovation and breakthroughs, but masterful marketing as well. The American public must be sold not only on the environmental value of EVs but on their practical transport, safety and economic value as well. The legislation which serves as the centerpiece of this hearing is, in our view at the L. A. Department of Water and Power, a vital component in this campaign. By incentivizing the process of developing and fielding a significant number of EVs, we will accelerate not only the technology but the marketplace acceptance of the EV option. We will contribute to making EVs the consumers' choice.

Additional local actions will be needed, of course, such as those being considered by the Los Angeles City Council. In fact, our Council has approved in concept an ambitious array of measures which are designed to accelerate the introduction of

EVs into the lifestyle of the average citizen. Examples of these actions include:

- making certain all new construction -- both residential and commercial, as well as parking structures -- includes accessible recharging facilities;
- providing discounted parking for EVs;
- providing special access even to single-occupant EVs in HOV lanes;
- providing for all units of L. A. City government to accomodate fleet usage of EVs (not just the DWP); and
- requiring that electric transport elements be included in all aspects of the local planning process, both for general and specific plans, and even in reviewing conditional use permits.

To date, these local actions have been approved by Council committees and, at least in concept, by the full City Council. Additionally, the Council is preparing to field an intra-city task force to coordinate the implementation of such EV strategies city-wide.

Finally, the City of Los Angeles intends to sponsor legislation in the California Legislature next year which will add state incentives to EVs similar to the local ones mentioned earlier. These incentives may include waiver of either or both sales taxes and registration fees for EVs.

I have no doubt whatsoever but that the public will choose EVs in the end. Our job in this crucial public/private consortium, which includes a partnership with the Congress, is to begin bringing the debate to an end and to act soon to spur the production of -- and public confidence in -- EVs. We view as most crucial, may I say, that portion of H. R. 3852 which commits the government dollar to bridging the cost differential between the anticipated higher cost at market of EVs compared to traditional vehicles. We believe this approach aims at the bull's eye of the problem still to be overcome.

We urge prompt action and passage of H. R. 3852 and will so urge the considerable -- and in view of the preliminary results of the 1990 Census -- still growing California Congressional Delegation.

I thank you, Mr. Chairman, for your leadership. With permission, I will provide a written statement and materials concerning the Los Angeles Electric Vehicle Initiative and the Playa Vista electrified roadway for inclusion in your hearing record.

I would be pleased to respond to any questions you or your colleagues may have.

Thank you.

Mr. TORRICELLI. Thank you, Mr. Gage. That was very helpful. It is an example of the fact that the leadership on what, ironically, is a national issue, now rising to international crisis proportions, is coming from local government—in this instance, some very thoughtful ideas and some suggestions, indeed, I had not heard before, but I thank you very much for your testimony.

Mr. Steinke of New Jersey Public Service Electric and Gas, welcome.

Mr. STEINKE. Thank you.

Mr. Chairman, I am Robert Steinke, Vice President of the Business Unit Development for Public Service Electric and Gas Company. We are located in Newark, New Jersey, and on behalf of PSE&G I commend you, Mr. Chairman, for your conducting this timely hearing on electric vehicle.

PSE&G strongly supports H.R. 3852 and urges the subcommittee's prompt and favorable consideration of this important proposal. H.R. 3852 addresses the dual problems of our high initial electric vehicle purchase price and the lack of consumer familiarity with electric vehicles, and that hampers today the commercialization of the electric vehicle technology.

In lieu of a separate written statement, PSE&G along with Southern Cal Edison, has associated itself with the written testimony of the Electric Transportation Coalition. I am jointly submitting that written statement for the hearing record today.

PSE&G is an investor-owned utility company, electric and gas, with approximately 13,000 employees. Our company serves approximately 5.5 million people in a square mile radius of about 26,000 square miles, and that runs across the State through our industrial/commercial corridors. Our highly diversified and heavily populated area in New Jersey consists of six major cities as well as nearly 300 suburban and rural communities and three-quarters of the State's population.

Now it may be no surprise to anyone in this room to learn that New Jersey's air quality largely does not meet the Federal standards for ozone. Nonattainment of carbon monoxide is also a major problem for us. New Jersey has the highest population density and most vehicles per square mile of any of the 50 States in the United States, and while technology advances, and prompted by Federal and State regulations, we have reduced vehicle emissions and increased fuel quality and efficiency, these improvements have not eliminated air quality problems in New Jersey.

In New Jersey, approximately 50 percent of the volatile organic compounds—VOC's—and 40 percent of the oxides of nitrogen, both precursors of ozone, come from mobile sources. Furthermore, motor vehicles are estimated to be responsible for 85 percent of carbon monoxide emissions in the State.

Now when you compare an electric vehicle to its gasoline counterpart, VOC emissions are reduced by 98 percent and carbon monoxide by 99 percent. In addition, nitrogen oxide emissions would also be significantly reduced, even taking into account the offset to the power plants.

We must encourage electric vehicles not only for the resulting benefits to our environment but also for electricity being a domes-

tic fuel resource, and it's abundant and it's stable and a good source of transportation fuel.

Over 60 percent of America's total oil consumption is used in the transportation sector. Iraq's invasion of Kuwait has demonstrated very vividly the dangers of continued over-reliance on foreign oil from unstable political regions of the world. The use of electric vehicles offers us in New Jersey and our Nation an effective means to cut our dependency on petroleum as a transport fuel.

Current electric vehicle technology using lead acid batteries can meet a variety of fleet applications for vehicle operators and particularly in our urban areas. Now the next generation of electric vehicles using advanced batteries, such as nickel-iron, promise increased range, acceleration, and a broader application.

We at PSE&G will soon be acquiring 10 full-sized electric G-Vans which we intend to employ in our fleet for demonstration and familiarization to our customers and our service territory to demonstrate the benefits of electric vehicles. In addition, we will be participating in regional users groups with New York utilities to share the data that we will learn and experience of electric vehicles.

We believe that our electric vehicle demonstration efforts will receive a favorable reception from our customers, but we are also faced with national surveys that show customers are reluctant to embrace this new technology in the short term. In large part, this reluctance stems from a lack of familiarity with the vehicle and how it is used. That is why it is important for us to demonstrate to our customers that this technology is a capable technology in the future and has national benefits as well as individual benefits for environment and security.

The real test for electric vehicles will not come in the laboratories or on the test tracks, it will be in the marketplace. While many challenges remain with respect to advancing and perfecting the vehicle itself and the batteries associated with it, the greater task is to shape the electrical vehicle technology in a way that meets the customer's demand and have the customers securely buy and use the vehicle.

Now I believe that Government and industry must work together to reach that goal. The efforts of the private sector to encourage alternately-fueled vehicles must be supplemented with public initiatives. Many States and localities are becoming increasing active in this area. We at PSE&G have advocated the creation of specific incentives to encourage the use of electric and gas vehicles as part of our Project Clean Air. This is a Statewide program to define policies that address the air quality issues facing New Jersey and will culminate in reducing our ozone and carbon monoxide limits.

We also believe, however, that incentives at the Federal level are needed if electric vehicles are to become a commercial reality. The Electric Vehicle Technology Development and Demonstration Act of 1990, H.R. 3852, will provide those incentives to resolve the market-based barriers to commercialization.

The problems of high vehicle cost and the lack of customer familiarity with technology create a Catch-22 situation that frustrates us to get to commercialization. H.R. 3852 offers meaningful incentives for the establishment of an electric vehicle production capability, and it provides Federal cost sharing to keep the vehicle costs at a

consumer level. If the product is good—and we believe it will be—and the price is right—and I think it can be—the customer demand will follow. The convergence of environmental and energy security issues today make it extremely important for us to take action to encourage this commercialization.

Electric vehicles are uniquely suited to respond to both the air quality and economic and energy security issues that we face in this Nation today. I am glad that the public and Congress is taking this kind of action today. Congress should send a clear, strong signal to the marketplace that electric vehicle technology development and commercialization are high national priorities.

In sum, from our own perspective in New Jersey, we believe that electric and natural gas vehicles can play a significant role in improving our air quality. Greater visibility of electric vehicles is a key to customer acceptance, and we strongly support H.R. 3852 as a catalyst to increased domestic vehicle production and its distribution. We must begin now to acquire a broad base of customer feedback that will identify customer interest and thereby attract the involvement of manufacturers. We simply do not have the luxury to wait for technology to catch up.

Without a production incentive program, electric vehicles will continue to be produced only in near-term very small quantities and at prohibitive costs. This is why H.R. 3852 and its approach to reducing the cost differential for these vehicles between gasoline-powered and electric is important to us.

All regions of the country, and particularly those in New Jersey, containing significant air quality problems, like New Jersey, must have the opportunity to experience the benefits of electric technology. We recognize that the time remaining in the current legislative session is limited. We urge this subcommittee to do everything it can possible to ensure that electric vehicle technology development and the demonstration act, H.R. 3852, is favorably considered into law.

I thank you very much for your time, and I'll be pleased to answer any questions, Mr. Chairman.

Mr. TORRICELLI. Thank you, Mr. Steinke, and I want you to know personally how pleased I am, both as a Member from New Jersey and, more than that, as a customer of your company, how proud I am that you have taken a leadership role in this and that you share this commitment. It is a real source of pride for all of us in New Jersey.

Mr. STEINKE. Thank you.

Mr. TORRICELLI. In the interests of time, because there is a vote, Mr. Brown has been kind enough to offer to chair the hearing and receive Mr. Geddes' testimony while I run very quickly to cast a vote so that we can proceed.

Mr. Brown, if you would take the chair, and, Mr. Geddes, if you would proceed.

Mr. GEDDES. Thank you, Mr. Chairman, Mr. Brown, members of the subcommittee. I'm very pleased to have the opportunity to be here today.

My name is Ray Geddes. I am Chairman and Chief Executive Officer of Unique Mobility, Inc., which is located in Englewood, Colo-

rado. I'm also Vice Chairman of the Electric Vehicle Association of the Americas.

As you can imagine, we and our neighbors in the metropolitan Denver area are acutely aware of the national need to conserve energy and to improve air quality. We Coloradans work very hard to produce energy, yet we, like many others in our great country, are faced with the unhappy consequence of having to live and work under a brown cloud.

By way of introduction, the company for which I speak is a publicly-owned small business which is committed to the development and production of commercially viable, environmentally clean vehicles, electric vehicles, which we are developing to meet or exceed the operating range, performance, and fuel economy of their conventionally powered counterparts.

Unique has been in business for 23 years, and has been active in electric vehicle development for 15 of those years. We are a participant in the Los Angeles Initiative which, as Mr. Gage has said, has as its goal the introduction of at least 10,000 electric vehicles into Southern California by 1995.

Unique Mobility strongly endorses the testimony given today by Mr. Bryson and Mr. Steinke and Mr. Gage, as well as the full written statement of the Electric Transportation Coalition. This testimony, we believe, correctly highlights the environmental and energy-related benefits of electric vehicles as well as the need for Congress to act now to assure the realization of those benefits over the near term.

I would like to speak to you, however, from a somewhat different perspective, and that is from the perspective of a veteran producer of electric vehicles. And the message I bring is this: that we, and others like us, organizations large and small, have now the technology in hand to produce significant numbers of electric vehicles and electric vehicle components during the early 1990's. Please allow me to amplify on that statement.

We launched our Electric Vehicle Development Program over 15 years ago. By 1982, we had produced, with private capital, a pilot run of 50 federally-certified battery-powered "Electrek" passenger cars. Most of these vehicles, which were purpose built from the ground up, were placed in fleet service with DOE-sponsored site operators, where many continue to be operated. The operating results from these fleets have provided much valuable data and has, we believe, established the ElekTrek as the international standard for EV passenger car performance. More importantly, the real world experience and expertise gained from these precursor EV vehicles gave us a firm foundation from which to launch new EV programs much more rapidly, and with much greater confidence than otherwise would have been possible.

Building on this effort, Unique, in 1988, entered into an arrangement with Alcan Aluminium Limited, the world's largest supplier of primary aluminum, to launch what we called Project Amoeba, a three-year advanced electric vehicle development program. The funding provided by Alcan has brought Unique's total investment in EV-related technologies to nearly $14 million. From this investment, we now have several promising developments that we believe

are ready for the marketplace, and I would like to summarize them briefly.

First is an advanced electric drive system which reduces component mass by more than 175 pounds and component volume by nearly two cubic feet—that is very important in an electric vehicle—and this system also increases system efficiency by more than 20 percent, which is also very important when the energy supply in the vehicle is very limited.

Secondly, we have a producible electric minivan prototype with superior performance and extended range capability that can be engineered and certified for limited production—that is, 1,000 to 2,000 units a year—within two years.

Third, we have a method of using a small, ultra-low-emission internal combustion engine generator to extend the range of conventional lead-acid batteries as a bridge to the time when a practicable advanced battery or fuel cell system becomes available, and I was pleased to hear Mr. Davis mention that the Department of Energy is interested in the range extender concept as well.

Fourth, we have a natural-gas-powered, hybrid, electric drive system that has been installed in an experimental minivan, and soon will be installed in a 25-foot intra-city transit bus.

And fifth, and finally, we have an advanced vehicle development program currently in the planning stage which envisages a purpose-built platform for an all-electric or hybrid-electric passenger vehicle incorporating a light-weight structure of adhesively-bonded recyclable aluminum.

All of these developments are more fully described in the separate written statement which we have submitted for the hearing record, and I urge you to read it, and I cordially invite any of you to visit us in Denver, where you can ride, and drive, and kick the tires of some of these vehicles which we have in daily service and which we believe are ready for market now.

In spite of these promising developments, however, it has been brought to our attention during the course of this hearing and at other times that there are those who may feel that it is too soon to bring electric vehicles into the marketplace, that the technology is too new; or that it is too old, or that batteries are impotent; or that small producers are too small; or that if we can only wait a few more years, major auto makers will see the light, if not the dirty air, and bring EV's to market en masse before the turn of the century. With these voices, we must take issue.

Many major auto makers do, in fact, have serious and highly commendable EV programs under way, but they are also far away. None of these programs, to the best of our belief, will be on line in significant numbers within the time frame, for example, of the Los Angeles Initiative. All of them, we believe, will start slow to test the water with pilot runs of a few hundred or a few thousand units, a task that, with the passage of H.R. 3852, we think can and should be accelerated by as much as three to five years.

Indeed, the sole point and purpose of H.R. 3852, as we understand it, is to provide incentive to specially manufacturers to start this process early by serving those markets that major auto makers historically avoid, overlook, or neglect. Markets that include specialized commercial vehicles, van pool conversions, airport shuttles,

intercity transit buses, and other highly visible niche-market product offerings.

We, on the other hand, as a specialty vehicle and component manufacturer, are ready and willing to commit our resources to bring electric vehicle technology to the market today. As a small business, we cannot, by ourselves, impact the marketplace and hence the environment to any large degree, but in partnership with others, both Government and private industry, there is much we can do.

The Los Angeles Initiative is an outstanding example of how such a partnership can work. A true test of both product and market, the Initiative can provide research data relative to the fleet operator's perception of EV price, performance, and range. It can provide real world component evaluation of state-of-the art battery technology, advanced traction drives, and range extender systems. It can provide product and manufacturing process feedback that will establish an early warning identification of areas that might require attention before heavy investment production programs are launched, and it can provide a head-start program to train dealers in the techniques of selling and servicing electric vehicles. All of these benefits will serve to smooth the way for larger volume producers to enter the market more quickly and with greater assurance than they otherwise would. If they do, and when they do, the need to seed the market with significant incentives will lessen and eventually disappear.

In the meantime, however, incentives will be required to accelerate EV programs already in place; to support initiatives such as that in Los Angeles; to encourage battery and fuel cell manufacturers to undertake large-scale production; to encourage auto makers outside of Detroit, who, by the way, supply more than half the passenger cars sold in Southern California, to bring their technology to the table; and, equally important, incentives will serve to increase the public and private awareness that Congress is concerned about the Nation's dependence on fossil fuels and the need to improve air quality.

Passage of the Brown bill, we believe, is essential to this process. H.R. 3852 is a logical companion to, and extension of, the Electric and Hybrid Vehicle Research and Development and Demonstration Act of 1976, which, as you mentioned, Mr. Brown, you were instrumental in getting passed, and it will facilitate implementation of regional initiatives such as that already in place in Los Angeles. It will supplement and support our national commitment to clean air and energy independence.

Therefore, we respectfully urge the subcommittee to act favorably and with dispatch to facilitate the enactment of H.R. 3852 into law.

Thank you, and I will be happy to answer any questions.

[The prepared statement of Mr. Geddes follows:]

STATEMENT OF UNIQUE MOBILITY, INC.

before the

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

September 25, 1990

This statement is submitted on behalf of Unique Mobility, Inc., (Unique), a publicly owned research, development and engineering company whose EV technology is being funded, in part, by Alcan International Limited, a wholly owned subsidiary of Alcan Aluminum Limited (Alcan).

Unique and Alcan strongly support the provisions of H.R. 3852, the Electric Vehicle Technology and Development Act of 1990. Unique, with the support of Alcan has place an extremely high priority on the place of electric vehicles in our corporate strategy. We have several internally funded and cooperative efforts already in place to promote the development and commercialization of EV's. We believe the implementation and commercialization of these efforts can play a vital role in fostering the establishment and early growth of the fledgling an fragile electric vehicle industry - an industry that will take on ever increasing significance in light of recent events in the Persian Gulf and the global concern over air quality. H.R. 3852 represents and important, if not essential, step toward moving our technology from the laboratory to the marketplace.

COMPANY PROFILE OF UNIQUE MOBILITY, INC.

Unique is a Colorado based engineering company which has as its goal the development of commercially viable "clean" vehicles which will utilize electric propulsion to achieve much greater range, performance and economy than their conventionally powered counterparts.

Organized in 1967, Unique develops and produces prototype vehicles, electric vehicle propulsion systems and high power

of Unique's efforts to develop a practical electric drive train for the car of the future.

Unique launched its electric vehicle development program in 1973. By 1982, the company had completed, with private capital, a pilot run of 50 federally certified ElecTrek all-fiberglass passenger cars. Most of the vehicles from the pilot run were placed in fleet service with the U.S. Department of Energy sponsored site operators where many continue to be operated. The operating results from these fleets have provided baseline data which even today establishes the ElecTrek as the recognized standard for EV performance.

Another of Unique's special vehicle accomplishments includes the design and construction of a five ton hybrid-electric camera vehicle which was used by ABC Television at the 1984 Olympics in Los Angeles for the live broadcast of the women's and men's marathon events. This vehicle - the UNIQ® Turbo-ElecTrek - carried three broadcast TV cameras, seven TV monitors, a self-contained power supply and a crew of 10. Its live video signal was beamed by microwave to ABC's Hollywood studio for satellite transmission around the world - a mission never before (or since) completed by an electric vehicle.

In 1986, Unique was contracted by General Dynamics Land Systems to build a concept demonstrator of an unmanned anti-tank weapon, the Tele-operated Mobile Anti-Armor Platform (T-MAP), which contained a diesel powered hybrid electric drive system. Unique traction motors with integral gear reduction were mounted to each wheel hub. The T-MAP weapons platform was fully functional and included four AT-4 anti-tank missiles and a vision system for target acquisition and firing. The vehicle was successfully tested at the Honeywell test range where it scored several remote fired hits at a distance of 450 meters.

In 1987, Unique was contracted by the U.S. Naval Surface Warfare Center (NSWC) to design and build a hybrid-electric robotic fire-fighting vehicle with all-wheel drive, all-wheel 360° steering and an adaptive suspension. The vehicle, completed just this month, can out-corner, out-climb and out-maneuver any known wheeled vehicle and will accommodate a variety of on-board payload packages and sensor suits.

Also in 1987, Unique was awarded a contract from NSWC to build a 10 kW Stirling engine generator. The engine incorporates a Unique alternator inside the crankcase so that all working components are contained in one compact hermetically sealed package. It is believed this device can serve as an ultra-clean, thermally efficient primary power source for a number of hybrid-electric vehicle applications.

Related work currently in progress at Unique involves the application of Unique's proprietary motor technology to various electric drive and/or motion control systems for NASA, the U.S. Naval Air Command, the David Taylor Research Center and the Unmanned Ground Vehicle Joint Program Office.

In 1988, Unique entered into an arrangement with Alcan Aluminium Limited (Montreal), the world's largest supplier of primary aluminum, to launch Project Amoeba - a three-year advanced electric powertrain development program. Unique and Alcan hope this joint development program will lead to the high volume production of advanced traction motors, generators, electric flywheels and associated electronics for a wide range of future battery-electric and hybrid-electric passenger cars and commercial vehicles.

One of the first and most dramatic results to emerge from Project Amoeba was the use of Unique's advanced brushless permanent magnet motors in 18 of the 32 university solar race car teams which completed in the 1990 General Motors - DOE - SAE sponsored "Sunrayce USA". All 18 of the entrants that chose Unique motors did so because of their unexcelled power density and efficiency and all 18 finished the grueling 1600 mile race with flying colors.

Unique Mobility is a publicly held company headed by Ray A. Geddes, Unique's Chairman and Chief Executive Officer, and John S. Gould, President and founder. Alcan currently owns approximately 16 percent of Unique's common stock and holds one seat on the Company's Board of Directors. Unique's stock is publicly traded.

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THE PLACE OF ELECTRIC VEHICLES IN UNIQUE'S CORPORATE STRATEGY

Unique plans to build the future of the company on its historical base and to use its proprietary electric drive technology recently developed with Alcan as the building blocks of its future.

Historically, Unique's base business has been comprised of contract R&D and the design and assembly of specialty vehicles and vehicle subsystems. The contract R&D performed for customers by Unique to date has had an important value added impact to the company, since it was this externally funded R&D that supplemented its internal budget expenditures for electric vehicle development. Additionally, the vehicle design and assembly work performed by Unique over the years has enabled Unique to gain an understanding of a wide variety of applications in the niche markets of transportation that range from non-conventional automotive applications to unmanned underwater craft to mobile robots to electric wheelchairs.

The strategy that Unique plans to follow in the future is to organize in such a way as to enable it to continue in its base business, but also to expand into the growth areas that are ready for Unique's technology, such as the commercialization of electric vehicles. Accordingly, the company is forming three separate business units described as follows:

Contract R&D. This business unit will continue to be focused on electric drive with funded R&D to supplement its internally budgeted activities. Two major areas of work in this area are planned. The first is a continuation of the Alcan sponsored activity that is geared to further optimizing Unique's current brushless dc motor and controller technology, construction and testing of an electric flywheel and the development of related electric vehicle control electronics. The second is related to the Los Angeles initiative. This initiative is sponsored by the City of Los Angeles and Southern California Edison who are committed to providing financial and other support to encourage the development and production of 10,000 electric vehicles for use in Southern California between 1991 and 1995.

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Component Manufacturing. The component manufacturing business unit is the most important of the future activities of Unique and its function will be to commercialize the fruits of the Contract R&D effort. This unit will produce electric vehicle drive train components for Unique's entry in the Los Angeles Initiative and will supply components to other electric vehicle manufacturers, large and small, who can be expected to bring product entries to market over the next several years.

Electric Vehicle Conversion & Assembly. The third separate business unit currently being planned is one that Unique will launch only if further analysis deems it to be an economic undertaking. The hesitancy on the part of the company is created by the fact that historically the electric vehicle conversion and assembly business is not a viable endeavor, particularly for a small company. This is due primarily to the cost penalty that electric vehicle conversions must bear compared to conventional vehicles. If undertaken, this activity would be an outgrowth of the Los Angeles Initiative for the promotion of electric vehicles and it would be viable only if it some way is found to offset the conversion cost penalty to such a degree that the resulting product would be competitive in the marketplace. Unique's decision on this activity will be forthcoming in the near future, and should it be positive, Unique would become the first company to totally manufacture and market a federally certified ultra low emission vehicle in North America. It is conceivable that if Unique takes such a step, and other factors fall into place such as a continued rise in energy prices, Unique could spearhead and encourage others to join a vitally important alternative vehicle industry beginning with the California market.

In summary, it is Unique's corporate strategy to continue to develop cost shared electric vehicle components and demonstration vehicles and, if deemed economic, convert small quantities of regular production vehicles to electric drive for pilot programs such as the Los Angeles Initiative. Ultimately, Unique hopes to become a high volume component supplier to the automotive industry, should that industry undertake the serious production of electric drive vehicles.

OVERVIEW OF COOPERATIVE EFFORTS TO PROMOTE THE DEVELOPMENT AND COMMERCIALIZATION OF EVS

Since 1975, Unique has focused its principal R&D activities on the development of electric vehicles, including its "break through" traction motor technology which is described more fully below. The dollar amount spent for Unique funded and customer sponsored activities relating to this effort is shown in the following tabulation:

	R&D Expenditures ($ Millions)		
Fiscal Years	Unique Funded	Customer Sponsored	Total
1975-81	$ 5.0	$ -	$ 5.0
1982-88	2.3	1.3	3.6
1989-90(est)	0.3	5.1	5.4
	$ 7.6	$ 6.4	$14.0

Unique's future electric vehicle development efforts will be directed principally toward programs that can be cost shared with others so that substantially all of its internally funded activity can be directed toward the development of manufacturing processes related to electric motors, controllers and other components that eventually can be marketed to higher volume vehicle producers. An overview of these efforts is set forth below.

Project Amoeba Component Development. In June 1988, Unique entered into a research agreement with Alcan to develop electric vehicle drive systems. The research project - Project Amoeba -is funded by Alcan and is focused primarily on Unique's core technology which is comprised of advanced brushless dc motors, controllers, energy storage systems and associated electronics.

Unique's core technology is best described as a highly efficient, power dense electromagnetic transducer. Electromagnetic transducers can be used to transform electrical power into mechanical power (i.e., motors) and to transform mechanical power into electrical power (i.e., alternators and generators). Power density is critical in applications where size and weight are to be minimized and high efficiencies are necessary to reduce energy consumption.

Unique believes its technology represents a significant advance in the development of high power density brushless dc motors and the power electronics required to control them. The novel armature design of the Unique motor in combination with Unique's advanced electronic control technology enables the reduction in size and weight of a typical motor drive by a factor of three or four times over today's most advanced machines of comparable performance. Moreover, Unique has achieved motor/controller system efficiencies greater than 90 percent over most of their usable range, with peak efficiencies in excess of 95 percent. To the best of our knowledge, no else has been able to achieve such performance in a motor drive suitable for a vehicle propulsion system.

A typical vehicle propulsion system utilizing this technology would be comprised of two or four traction drive modules, each consisting of a motor, controller and speed reducing gear set. Because the Unique motor is essentially hollow, the gear set is capable of being packaged inside the motor proper, further reducing the overall space claim of the module. The energy source to power the drive modules may be provided by an on-board engine/generator (electric transmission system), a battery or fuel cell (pure electric system) or a combination of the two (hybrid electric system).

A promising additional component for such a system is the kinetic energy storage device (flywheel) which Unique is currently developing in conjunction with the University of Ottawa (Canada) as part of Project Amoeba. This device integrates a Unique motor/alternator into a composite flywheel which is housed in a hermetically sealed evacuated container with only electrical input and output. The function of the flywheel is to store (kinetically) energy recovered from regenerative braking and release it (electrically) on command for peak power requirements. With such a device, the primary energy source (engine-generator or batteries) can be downsized to provide average propulsion power, and energy otherwise dissipated as heat in the braking mode can be recaptured and applied for acceleration power. In a typical urban driving cycle, such a system could theoretically result in an energy savings of 50 percent or more.

The advantages of an integrated electric drive system over conventional mechanical drive systems are many, particularly when viewed in the context of the

growing global concern over air quality and energy conservation. Key among them are the following:

- The ability to eliminate completely or to utilize downsized internal combustion engines operated at constant speed and electronically managed for optimum fuel efficiency and lowest emissions.

- Full utilization of regenerative energy from braking, which dramatically improves system efficiency in the urban driving cycle.

- Total traction control (anti-skid, anti-slip, anti-spin) made possible by a fully computer controlled "drive-by-wire" electric transmission system.

- Elimination of most mechanical transmission, differential and drive shaft hardware which provides the design flexibility to alter body shapes in order to improve vehicle aerodynamic efficiency.

Unique estimates that approximately 40 to 60 pounds of recyclable fabricated aluminum products per vehicle would be required for such an advanced electric drive system. This poundage would be in the form of die castings and extrusions for motor casings, end plates and electronic heat sinks, and would reduce the weight of a typical conventional drive system by as much as 300 pounds.

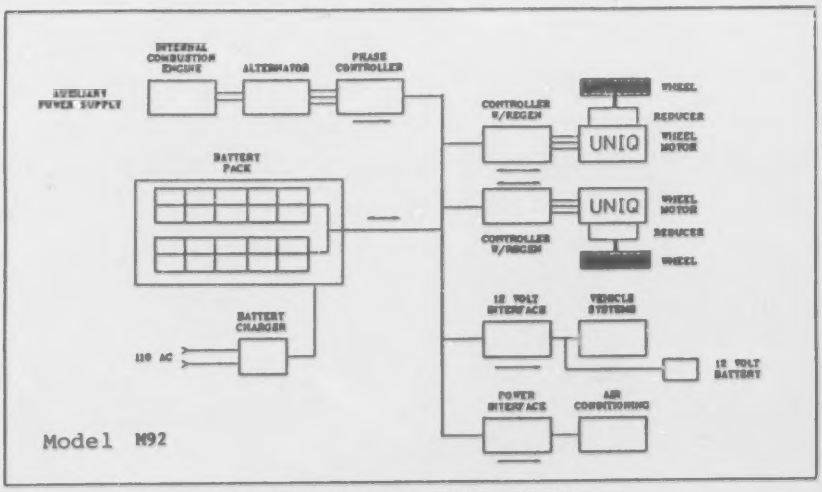
It is the objective of Project Amoeba to demonstrate these advantages by developing engineering test vehicles which incorporate the basic engineering concepts of the Unique drive train components and related control electronics. The technology path from component development to the integration of components into a vehicle system (i.e., vehicles for the Los Angeles Initiative) is a vital first step in Unique's effort to help create an electric vehicle industry in the United States.

The Los Angeles Initiative. In November 1989, Unique was identified as one of the winners of the "Los Angeles Initiative," a program designed to

encourage the introduction of electric vehicles into the Southern California commercial fleet market. The program is sponsored by the City of Los Angeles Department of Water and Power. The sponsor is committed to providing financial and regulatory support, in amounts and by methods not yet totally defined, sufficient to support the production of 10,000 electric vehicles for sale to Southern California fleet operators between 1990 and 1995.

Unique's proposed electric vehicle -- designated as the Model M-92 -- is based on a minivan platform such as the Chrysler minivan Ford Aerostar. A technical description of the proposed vehicle is contained in Attachment 1. This type of platform was selected because of its utilitarian configuration, volumetric cargo capacity, light weight and low drag characteristics. Minivan platforms in general have also achieved a high level of acceptance in the growing North American commercial van market.

Depicted below is a schematic drawing of the Model M-92 powertrain. The system consists of 18 gelled electrolyte low maintenance sealed lead-acid batteries with a small internal combustion engine-generator which can be used to extend the daily driving range to over 100 miles. The batteries, located beneath the vehicle floor, are recharged by an on-board charger that operates from a 240 v ac power outlet. The fuel tank for the engine-generator, also located beneath the vehicle floor, can be adapted to supply either natural gas, liquid propane or methanol. With this system, there is no intrusion into the passenger compartment or cargo area of the vehicle.



UNIQ M92 POWERTRAIN SCHEMATIC

The traction system incorporates two 50 kW UNIQ® brushless dc motors in an independent two wheel drive system. As shown in the above schematic, each traction motor operates from signals produced by a dedicated controller. A single ratio gear reduction is used to link each wheel motor to its respective road wheel. Reverse is accomplished electronically. Regeneration is also derived from the controllers, which convert kinetic energy during braking into electrical energy to recharge the battery pack. Overall traction efficiency is estimated at 85 percent and efficiency during regenerative braking at 80 percent. The air conditioner operates from a power interface unit connected to the 120v battery pack. Normal 12v auxiliary systems operate from the main battery pack through the use of a 12v 40 amp converter. A small 12v battery provides standby power during non-driving periods.

The engine-generator is a 12 hp 4-cycle water cooled internal combustion engine driving a UNIQ® alternator which has a nominal 5 kW rating. It typically operates less than one-half of normal driving time except when the air conditioner is running. The engine can operate on liquid propane, natural gas or methanol with negligible emissions. Reformulated gasoline serves as base fuel; fuel consumption when operating is approximately 0.5 gallons per hour.

The engine-generator operates at constant speed in two power ranges which allows for optimum tuning within those ranges. The alternator output feeds into a common electrical bus for distribution either to the traction motor or to the batteries to supplement battery power (charge the batteries). In the higher power range, the alternator supplies the required additional power for air conditioner operation. The engine never produces power that is not needed (i.e., it does not idle). The on/off mode is manually determined by the operator.

Unique is presently negotiating with the City of Los Angeles to obtain funding to undertake a 24 month program to production engineer and certify the Model M-92 to Federal Motor Vehicle Safety Standards (FMVSS), and with Ford Motor Company to secure a supply of base vehicles which can be converted to electric drive. Assuming a program start date of October 1990, volume production could begin in mid-1992. Current plans are to produce 1,000 units during 1992 and 2,000 units in 1993.

Unique plans to establish a sales and service infrastructure sufficient to support its production program in the Southern California counties of Los Angeles, Ventura, Orange, San Bernardino and Riverside. The infrastructure will be comprised of selected separately franchised OEM dealers and qualifying full maintenance fleet operators.

The Los Angeles Initiative is Unique's most ambitious new business opportunity. It represents a viable near term program to put a fully functional extended range electric vehicle on the road within two years. It will provide a "real world" test of the Company's electric drive system technology and, if successful, would represent an important step toward the possible integration of Unique electric drive components into regular production automotive assembly plants. However, because of volume related cost penalties, Unique will be unable to implement the production and marketing phase of this program without some form of outside subsidization to reduce the life cycle cost and/or purchase price of its product offering.

Range Extender Development. Unique is developing methods of extending the range (or reducing the number) of lead acid batteries as a "bridge" to the time when a practicable advanced battery or fuel cell system is available. The initial effort, a Honda 5 kW 4-cycle internal combustion engine (ICE) generator set, is described above.

However, Unique believes that a commercial recreational vehicle engine generator will not provide the optimum system for electric vehicle applications due to constraints of size, weight, voltage and power. Moreover, such engines have not been optimized for low noise, low emissions and extended duty cycles.

For these reasons, Unique is undertaking a joint development program with a leading international manufacturer of generator sets, to develop an application specific ICE range extender for use in electric vehicles. A 12.5 bhp engine has been selected as the ICE of choice. It is a single cylinder, OHV air cooled four cycle engine with a balancer shaft that with further development will be well suited for the application. The goal for the system is a weight of 125 pounds, excluding fuel, with emission levels well below the proposed California Air Resources Board Ultra Low Emission Vehicle (ULEV) standards for light duty

vehicles.

For the longer term, Unique and Alcan (with partial funding from the Ontario Ministry of Energy) are developing a non-fossil fueled range extender utilizing aluminum-air (Al-air) fuel cell technology presently being developed by Alupower, Inc., a wholly owned Alcan subsidiary.

A cell fueled by aluminum generates power through a simple electrochemical reaction between the metal, once placed in an alkaline solution, and oxygen from the air. Electricity is produced as the aluminum oxidizes. To recharge the cell, the aluminum plates are replaced and more electrolyte is added. The reaction product can be removed and then recycled through the aluminum process back to metallic aluminum.

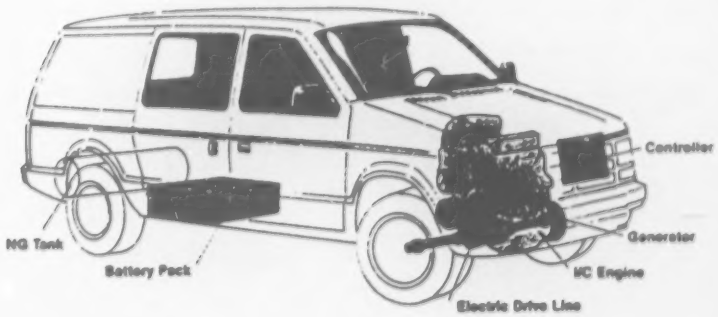
The objective of the Al-air project is to develop and package a 6 kW Al-air fuel cell into a battery powered minivan similar to the Model M-92 described above. The goal is to extend the range of the vehicle to 180 miles or more on the combined system before the fuel cell must be mechanically recharged.

CNG Hybrid Electric Minivan. Unique has been contracted by San Diego Gas & Electric (SDG&E) to develop a compressed natural gas (CNG) Hybrid Electric Minivan demonstration vehicle as a spin-off of the Model M-92 minivan being readied for the Los Angeles Initiative. Being an electric utility, SDG&E is naturally investigating electric vehicles. But SDG&E is also a major supplier of natural gas, a very clean burning fuel. It is the goal of this project to combine the company's two primary products - natural gas and electricity - to overcome the range and performance limitations of the all-electric vehicle.

The hybrid-electric concept employed in the SDG&E project uses a "down-sized" ICE driving a generator as the primary mover to furnish average power. Additional power for peak acceleration and hill climbing is supplied by a set of rechargeable batteries. This approach differs from Unique's Model M-92 concept which utilizes a larger battery pack as the primary mover with help from an ICE range extender. It is intended, however, that the CNG hybrid would be sufficiently "clean" to qualify as an Ultra Low Emission Vehicle (ULEV) as

defined by the California Air Resources Board.

A seven passenger Dodge Caravan with extended wheelbase is used as the basic vehicle platform. The van includes power steering, power assist brakes and air conditioning. The two compressed natural gas tanks are located behind the rear passenger seat, and deliver a range of up to 200 miles. The conventional engine and front-wheel drive transmission were removed during the conversion to hybrid-drive.



An engine-driven UNIQ® alternator supplies normal driving power, with a battery pack furnishing supplemental power for hills and acceleration. An Engine Management System (EMS) controls engine rpm by monitoring battery and vehicle speed and constantly works to limit current draw on the battery. The 180 volt direct current battery pack is connected to a bus feeding the motor controllers. The power steering and power assist brake are operated by the battery pack. The air conditioning compressor, however, is operated by a belt drive connected to the engine. A 200 VAC battery charger system is incorporated into the test vehicle.

A Ford 1.1 liter (79 cu. in.) four cylinder engine was selected for the vehicle. It was chosen for its small size and light weight, and the fact that it could be supplied to operate on CNG directly by Ford. It is an industrial engine, built in Ford's factory in Valencia, Spain. The engine is less than half the size of the original 3.2 liter engine that it replaced. When combined with clean burning natural gas, vehicle emissions are expected to be cut drastically.

A total of 15, 12 volt sealed lead acid batteries are mounted in an aluminum and fiberglass battery tray between the front and rear axles. The battery pack is designed to slide out for easy access. Under normal circumstances, the 600 pounds of batteries will be charged by the engine alternator. The battery pack for a similar all-electric van would weigh more than twice as much.

Upon completion, a data acquisition system will be installed and the vehicle will be track tested and evaluated using the Model M-92 for baseline comparison. Commercialization plans are in the process of being formulated.

CNG Hybrid Electric Transit Bus. Unique is participating in a program to design, build and demonstrate the performance of a prototype multi-purpose transit bus which will be fueled by compressed natural gas (CNG) and will have a hybrid electric propulsion system. The propulsion system will be a scale-up of the system used in the concurrent program to develop a CNG hybrid electric minivan for SDG&E.

The vehicle will be built on an Orion II 25' low floor bus built by Bus Industries of America, Inc., and will be targeted for the following markets: (i) public transit, (ii) school bus, (iii) feeder bus and shuttle, (iv) medical aid and general purpose local delivery. The design will be sufficiently flexible to be manufactured in platform lengths of between 18' and 40'.

The Unique hybrid electric propulsion system will be the focal point of the development. It will consist of an ICE generator fueled by natural gas driving a pair of UNIQ® 50 kW traction motors. The vehicle will also have a battery storage system which will supply surge power for acceleration and other peak power requirements such as hill climbs and sustained highway speeds. The CNG storage tanks will be roof mounted to accommodate the low floor configuration.

The goal of the project is to develop an advanced design transit bus having similar driving characteristics to vehicles with conventional propulsion, yet realizing significant reductions in fuel consumption and tailpipe emissions. It will also serve as a rolling test bed for evaluation of the Unique electric

flywheel being developed by Unique and Alcan under Project Amoeba. Preliminary analysis has shown that regenerative braking energy stored in a flywheel could reduce fuel consumption in an urban bus start/stop driving cycle by as much as 50 to 60 percent.

The CNG hybrid bus project is being cost shared by Unique/Alcan with Bus Industries of America, Inc. who plans to produce and market the resulting product. Additional funding is being provided by San Diego Gas & Electric and the Ontario Provincial Government. Completion date for the first operable demonstration vehicle is December 1991.

Advanced Vehicle Development. Unique's advanced vehicle development program is being planned around a new platform for an all-electric or hybrid-electric passenger vehicle incorporating a lightweight structure of adhesively bonded recyclable aluminum.

For many years, adhesive bonding of aluminum has been used in aircraft construction to make lightweight, rigid, and durable structures. When applied to automotive designs, the same concept has resulted in structures as rigid as steel at half the weight. Since the key to strong and durable bonds is the pretreatment of the aluminum prior to bonding, and since the pretreatment techniques which had been developed for aircraft structures were not appropriate for volume car production, Alcan has developed a pretreatment system that combines high speed application with low cost. Funding partners for this program are currently being solicited. It is hoped that with a January 1991 program start, Unique and one or more collaborating vehicle manufacturers could be in production with a dramatically new, next generation electric vehicle within three years.

THE NEED FOR A FEDERAL INITIATIVE

Unique has associated itself with the Electric Transportation Coalition and joins the Coalition in the written views which are contained in its separate written statement that has been submitted for the hearing record.

In addition, we as a precursor electric vehicle manufacturer, would like to emphasize the vital role that we, and others like us, can play in bringing advanced electric vehicle technology to market. As a small business we cannot by ourselves hope to impact the marketplace - and hence the environment - in any significant way. However, in partnership with others, both government and private industry, there is much we can do. The Los Angeles Initiative, is an outstanding example of how such a partnership can work. As a true test of both the product and its market, the Initiative can provide the following benefits:

- Research data relative to the fleet operator's perception of EV price, performance and range.

- Real world component evaluation of state-of-the-art battery technology as well as the Unique/Alcan advanced traction drive and range extender systems.

- Product and manufacturing process feedback that could accelerate future regular production programs by providing the early warning identification of areas that might require attention before high investment programs are launched.

- A "head start" program to train dealers in the techniques of selling and serving electric vehicles.

All of these benefits will serve to smooth the way for larger volume producers to enter the market more quickly and with grater assurance than they otherwise would. If they do, and when they do, the need to "seed the market" with significant incentives will lessen and eventually disappear.

In the meantime, however, incentives will be required to accelerate R&D programs already in place, to support initiative such as that in Los Angeles, to encourage battery and fuel cell manufacturers to undertake large scale production, and to increase public and private awareness of efforts to decrease the nation's dependence on fossil fuels and improve air quality.

CONCLUSION

Unique Mobility, with the support of Alcan Aluminum Limited and under the auspices of the Los Angeles Initiative, is able to develop, certify and put a practical electric vehicle on the road in Southern California within two years. In addition, the Unique/Alcan partnership is developing a growing menu of advanced EV technologies that hopefully will find their way into automotive production lines in such higher volumes as the years go by.

Action at the federal government level is necessary to assure that the benefits from Unique's production of electric vehicles are realized in the near term. High per vehicle costs, as well as lack of actual on-the-road driving experience, have kept the demand for electric vehicles far below the level necessary to justify Unique's investment in production facilities. Without carefully designed incentives, it is likely that Unique will be forced to abandon its plan to bring an electric vehicle to market in Southern California.

Congress has an important opportunity to act now. The federal government can and should assume a leadership role in encouraging electric vehicle production and technology advancement to assure that the environmental and energy security benefits of EV's will be achieved. Unique urges that this principle be reflected in the favorable consideration of H.R. 3852 in this session of Congress.

Attachment 1

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SAE Technical Paper Series

900181

An Electric Van with Extended Range

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Unique Mobility, Inc.
Englewood, CO

Reprinted from SP-817 –
Electric Vehicle Technology

International Congress and Exposition
Detroit, Michigan
February 26 — March 2, 1990

The papers included in this volume are abstracted and indexed in the SAE Global Mobility Database.

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ISSN 0148-7191
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900181

An Electric Van with Extended Range

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Englewood, CO

ABSTRACT

The design and performance of an electric van with extended range capability is described. The vehicle platform is the Chrysler TI15 minivan. A low emissions, alternate fueled (CNG, LP, methanol), internal combustion engine auxiliary power unit (3 - 5 kW) is employed for range extension. SAE J227 C-cycle performance of 100+ miles is attainable using low maintenance gelled electrolyte lead-acid batteries. A prototype has been built and is currently being evaluated. Also described is the design of an advanced drive system for the vehicle employing light weight, high efficiency permanent magnet motors and a hermetically sealed electric flywheel for increased acceleration capability and higher efficiency during regenerative braking.

INTRODUCTION

Unique Mobility, Inc., is a small publicly held R & D company organized in 1967 and presently active in the design and development of vehicle propulsion systems utilizing its highly advanced brushless dc motor and control electronics. Unique launched its electric vehicle development program in 1972 and by 1982 completed a pilot run of 50 fully certified ElecTrek passenger cars, most of which were placed in service with DOE sponsored site operators. The operating data from these fleets has been extremely valuable to the industry and Unique.

Currently under development is an efficient electric and electronic power transmission system--an advanced dc brushless motor drive that is capable of operating from any available source of electricity such as primary batteries, on-board engine generators or fuel cells.

It is, however, this requirement for an available source of on-board electricity that poses the biggest technology hurdle. Based on current technology, there is no better way to package [illegible] on-board a moving machine than to use an internal combustion engine to convert a petroleum base [illegible] (gasoline) into mechanical energy. In the long term, there may be an economical on-board energy storage system that is both energy dense and capable of supplying enough accelerative power for a viable propulsion system.

At the present time, it would appear that the best available liquid electrolyte lead-acid battery system is capable of no more than a 60 mile range on the SAE J227a C-cycle. Gelled electrolyte versions can be expected to achieve considerably less. With air conditioning and other auxiliary system drains (power steering, brakes, lights, etc.), one might expect a C-cycle range of only 35 - 40 miles for today's "best" all electric vehicle. Such a limited range would prove unacceptable to the majority of users. A C-cycle range of at least 100 miles with all auxiliary systems functioning is a more reasonable objective for operation in an urban area.

Accordingly, as a "bridge" to the time when an advanced battery system is available, the limited range of the pure electric system may be extended by the addition of an auxiliary power unit (APU). The APU selected is a nominal 5 kW 4-cycle water cooled internal combustion engine generator which operates on alternative fuels at near zero emissions. By allocating 3 kW of APU output to propulsion and 2 kW to auxiliary systems, vehicle range with the air conditioner operating will be capable of meeting the 100 mile C-cycle range objective.

TECHNICAL APPROACH

Unique's electric vehicle design is based on the Chrysler TI15 minivan platform used in the Plymouth Voyager or Dodge Caravan. A typical minivan and component configuration is illustrated in Figure 1.

The T115 was selected as the base vehicle because of its front wheel drive low-bed configuration, its volumetric cargo capacity compared to other minivans and its light weight, low drag characteristics compared to standard size vans. It has also achieved a high level of market acceptance as the top selling minivan in North America.

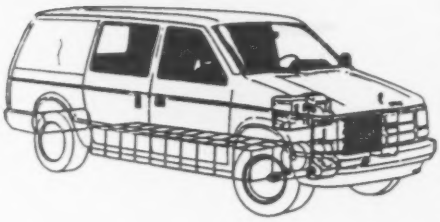

Figure 1. Mini Van Configuration

Prototype Design

An initial prototype has been built. The powertrain is portrayed schematically in Figure 2. This is a near term vehicle that can be produced with currently available and proven technology and is a pilot program vehicle to field test the various vehicle sub-systems in a real world environment.

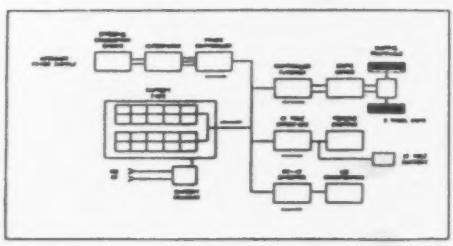

Figure 2. Prototype Powertrain Schematic

The vehicle uses lead-acid batteries and has a small APU driven alternator which can be used to extend the daily driving range. Nominal voltage of the system is 108v dc, as derived from two parallel packs of 12v battery modules. The batteries are recharged by an on-board charger that operates from a 240v ac power outlet.

The single traction motor is a shunt wound dc brush type that is matched to operate from signals produced by the solid state controller. The motor is mated to a manual 5-speed transaxle to provide four forward speeds and one reverse speed to the two front wheels. Regeneration is also derived from the controller, which converts the vehicle's kinetic energy during braking into electrical energy to recharge the battery packs. Overall traction efficiency from batteries to wheels is estimated at 80 percent. Regeneration efficiency during braking is estimated at 70 percent.

The APU is a 4-cycle water cooled internal combustion engine/alternator which has a nominal 5 kW rating. It typically operates less than one-half driving time except when the air conditioner is running. The APU can operate on liquid propane, natural gas or methanol. Liquid propane has been chosen as the base fuel and consumption when operating is approximately 0.75 gallons per hour.

Advanced Vehicle Design

The advanced vehicle design will incorporate Unique's high power density brushless dc motors in an independent two wheel drive (2 WD) system as shown in Figure 3. The motors are of the permanent magnet brushless dc type which require no electrical field generation.

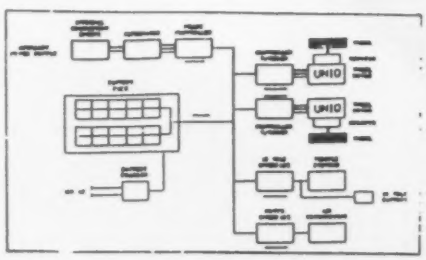

Figure 3. Advanced Powertrain Schematic

As shown in Figure 3, each traction motor operates from signals produced by a dedicated controller. A single ratio gear reduction is used to link each wheel motor to its respective road wheel. Reverse is accomplished electronically. Regeneration is also derived from the controllers, which convert kinetic energy during braking into

electrical energy to recharge the battery pack. Overall traction efficiency is estimated at 85 percent (vs. 80 percent on the prototype vehicle) and efficiency during regenerative braking at 80 percent (vs. 70 percent on the prototype vehicle). The air conditioner operates from a power interface unit connected to the 120v battery pack. Normal 12v auxiliary systems operate from the main battery pack through the use of a 12v 40 amp converter. A small 12v battery provides standby power during non-driving periods. The APU will be similar to that employed in the prototype design.

The vehicle can also utilize an advanced energy storage system. The two leading candidates at this time are nickel-iron (Ni-Fe) and sodium sulphur (NaS) batteries. If the energy density of such batteries proves sufficient, the APU range extender may become unnecessary.

Flywheel Option

Electric flywheel technology is also being developed. Figure 4 illustrates a future (2 years) vehicle powertrain with the flywheel option. The flywheel stores and releases energy recovered by regenerative braking more effectively than batteries. The flywheel also provides a load leveling for the batteries which extends their capacity by providing peak power during acceleration. Traction efficiency remains constant at an estimated 85 percent, but regeneration efficiency should be increased to 85 percent. The use of an electric flywheel may also permit utilization of advanced lead-acid batteries expected to be available within a 2-3 year time frame.

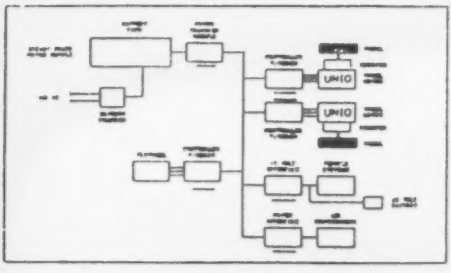

Figure 4. Powertrain With Flywheel Option

On a long term basis, development of an advanced new platform for an all electric multipurpose vehicle (MPV) incorporating a structure of adhesively bonded aluminum is envisioned. The process of adhesively bonding aluminum as recently developed by Alcan can be utilized to fabricate a non-corrosive all aluminum body-in-white at roughly the same cost as steel, but at half the weight.

As currently planned, such a vehicle would incorporate a common platform chassis that could accept a number of upper body structures (e.g., van, station wagon, pickup, sedan, etc.). A typical upper body configuration is shown in Figure 5. Modular traction motor/suspension assemblies would be mounted to the chassis for independent 2 WD or optional 4 WD. A composite longitudinal torque box would house the battery pack and a cooling duct for thermal management. Special attention would be given to aerodynamics with a drag coefficient goal of 0.3.

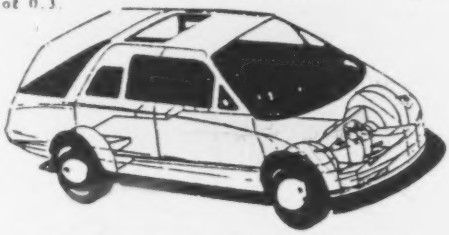

Figure 5. Aluminum Structured Multipurpose Vehicle (MPV)

COMPONENT DESIGN SPECIFICATIONS

Traction Drive Systems

The traction motor utilized in the prototype powertrain system is described below:

Prototype Vehicle Traction Motor:

Type:	Brush Commutated, Shunt
Manufacturer:	General Electric (GE)
Insulation Class:	F
Voltage Rating:	120 V
30 Second Rating:	500 A
Hp Rating:	60 KW (80 hp)
Weight:	135 kg (300 lb)
Size:	0.2794 m (11 in.) dia.
	0.508 m (20 in.) long
Max. Speed:	6000 rpm
Base Speed:	2000 rpm

The prototype traction motor is similar to those that have been used successfully in the ElecTrak as well as in several other electric vehicle programs. The average traction efficiency from the dc battery source to the wheels is estimated to be on the order of 80 percent. The motor is connected to the standard 5-speed manual transaxle as supplied by Chrysler. The powertrain is illustrated in Figure 6. Total powertrain weight is estimated at approximately 400 lbs.

Figure 6. Prototype Vehicle Powertrain

As discussed above, the advanced vehicle drive train will incorporate high power density permanent magnet (PM) motor technology. Two motors will independently drive the front wheels. Each motor is nominally rated at 50 kW at 7500 rpm as shown in the table below:

Advanced Vehicle Traction Motor(s):

Type:	Brushless dc
Manufacturer:	Unique Mobility
Insulation Class:	H
Voltage Rating:	120 V
Current Rating:	400 A
Hp Rating:	50 kW (67 hp)
Weight:	15 kg (33 lb)
Size:	0.226 m (8.9 in.) dia., 0.140 m (5.5 in.) ling
Max. Speed:	7500 rpm
Rated Speed:	7500 rpm

As can be seen from the above tables, the use of two high power density PM motors versus the single GE motor represents a savings of 234 lbs in motor weight alone. Each motor is connected to a single ratio reduction unit. Overall average traction efficiency of the drive train is estimated at 85 percent. Figure 7 illustrates the powertrain for the advanced vehicle.

Figure 7. Advanced Vehicle Powertrain

Figure 8 shows an exploded view of the UNIQ motor. Performance of the motors to be used in the advanced powertrain is shown in Figure 9. Note the high efficiency over the full operating range of the unit--a consideration of great importance in a vehicle traction application. An automatic 2-speed electronic winding shift is being investigated to improve acceleration performance and gradeability. This device would electronically couple the motor stator windings in series or in parallel and thus achieve two speed-torque ranges from the same motors and controllers.

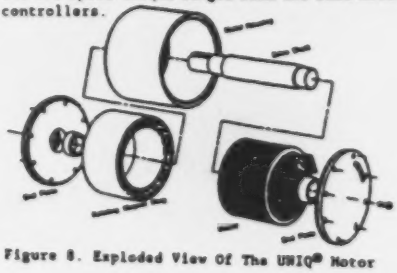

Figure 8. Exploded View Of The UNIQ® Motor

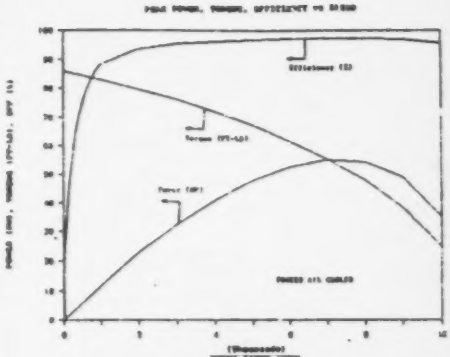

Figure 9. Performance Of 50 kW Motor

Motor Controllers

The motor controller to be used on the prototype powertrain provides current to both the armature and the separately controlled field of the motor. The combined motor/controller system is rated at 60 kW. During low speed operation, the field is fully energized. Speed control is accomplished by pulse width modulating the voltage applied to the armature. At higher speed (determined by battery voltage and load conditions, typically 2000 rpm) the field windings are given reduced amounts of current thereby causing the motor to operate in a higher speed, lower torque mode.

Regeneration is accomplished by controlling the field winding current. Regeneration will occur down to the 2000 rpm motor speed range described above. Below 2000 rpm, sufficient voltage cannot be generated to accomplish regeneration with this motor/controller system.

The controllers for the advanced powertrain will consist of two separate 50 kW 120v dc power inverters. These devices operate using pulse width modulation (pwm) of current to the stator only inasmuch the field is fixed by permanent magnets. The motors contain no brushes, thus the controllers must accomplish the commutation function electronically. This allows for electronic reversal of the motor, eliminating the need for a multiple step gear transmission. Figure 10 shows the basic controller topology. By pwm control of the stator winding, regeneration occurs down to practically zero rpm and results in higher regeneration efficiency. The controllers operate from control signals derived from the main vehicle control module which accepts input signals from the accelerator pedal, brake pedal, and elsewhere to determine motor speed and direction. Figure 11 is a photograph of the prototype 50 kW controller currently being developed for the advanced powertrain.

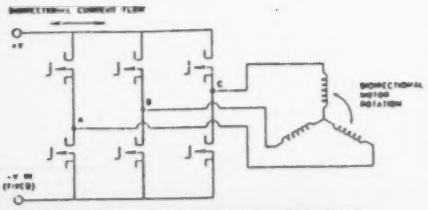

Figure 10. Basic Controller Topology

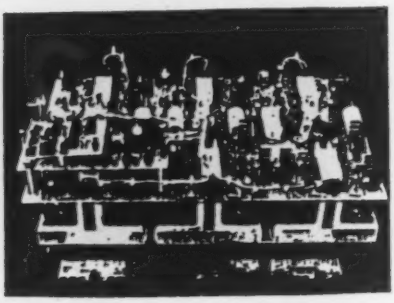

Figure 11. 50 kW Motor Controller

Battery System

A comparison of the several types of batteries which might be employed over the time frame of Unique's development program is shown in Figure 12. This graph illustrates the extent to which the specific energy content of a given battery in Wh/kg is reduced as the specific power output in W/kg is increased. Implicit in these relationships is the fact that peak power requirements for acceleration and high speed operation significantly affect the battery capacity available between charges. Specific characteristics of each of the several battery types are discussed below.

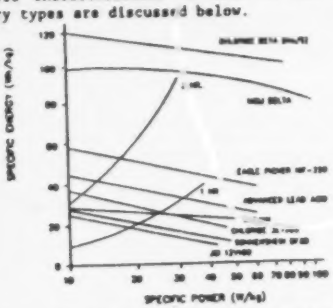

Figure 12. Comparison Of Various Batteries

Liquid Electrolyte Lead-acid

Lead-acid batteries are by far the most widely used in present vehicle traction applications. Typical energy density for this type of battery is generally in the range of 30 Wh/kg. Wet lead-acid batteries are typically the least expensive of the technologies being considered, but must be serviced approximately once per week to maintain electrolyte level--a major drawback. Because of battery inaccessibility, a single point watering system is often included at extra cost. Hydrogen gas emitted during the final phase of charging wet lead-acid batteries can create an explosive environment if the concentration of hydrogen reaches a four percent level in the local atmosphere. Therefore, ventilation must be provided in the charging area.

At this time two wet battery systems are under consideration: Trojan (Model EV8DC) and Chloride (Model 3ET205). The Trojan battery is a 12v module, requiring 10 modules for the 120v system. The Chloride battery is a 6v module, requiring 20 modules for the system.

Gelled Electrolyte Lead-acid

Gelled electrolyte lead-acid batteries offer a no maintenance alternative to the wet lead-acid system, but at reduced performance. The sealed lead-acid cell operates on a starved electrolyte basis where the gas emitted during charging recombines in the cell. This allows charging with no loss of electrolyte and no requirement for special ventilation. The sealed battery also eliminates possibility of acid leakage or spills.

The energy density of the gel cell battery is typically 20-25 Wh/kg. The charging requirement is also different from the wet cell. Gel cells charge initially in the same manner as the wet lead-acid type, but finish with a float charge rather than with a constant current requirement. Temperature compensation for end charging is very important and special attention must be given to vent design in order to prevent premature failure due to the low pressure condition that exists after gas recombination is complete.

Figure 12 compares two sealed lead-acid batteries: The Johnson Controls (Model GC12V100) and the Sonnenschein (Model DF8D). Both types are 12v modules. A total of ten modules would therefore be required for a 120v operating voltage. From the data, the Sonnenschein battery appears to be some what superior, although it is more costly as it is manufactured only in Europe at this time.

Nickel-Iron

The Ni-Fe battery (NIF-220), being developed by Eagle Picher, is a wet battery technology that offers an improved energy density of approximately 50 Wh/kg at the 3 hr (C/3) rate. The modules would also require single point watering and maintenance would be similar to that of a wet lead-acid battery.

system. Ni-Fe batteries also have a high ventilation requirement during recharging. Moreover, they must be overcharged to reach rated capacity. The overcharge rate increases as the battery gets older. The batteries are packaged in a standard lead-acid type case with a nominal voltage of 6v per module. Charging occurs at a high initial rate (45a) and at a moderate finish rate (20a) which results in shorter charging cycles. Projected life for NI-FE batteries at 100 percent of discharge is 1200 cycles.

Sodium-Sulphur

Sodium sulphur batteries are being developed by Chloride and Asea Brown Boveri/Powerplex. The sodium sulphur battery utilizes a solid electrolyte which separates a liquid sodium electrode from a liquid sulphur electrode. The electrolyte, which has an atomic structure of beta-alumina, allows sodium ions to pass through to react with sulphur to form sodium sulphide upon cell discharge. This technology has the advantage of possessing 100 percent coulombmetric efficiency. The cell package is in the form of pressed steel containers. The battery module is composed of hundreds of small cells connected in a series - parallel arrangement to arrive at the final output voltage. The battery must be maintained at a continuous operating temperature of 350°C (660°F) for both operation and recharge which is accomplished by heaters embedded in the battery system. Once the module is up to temperature, internal resistance during use helps to maintain the temperature. The battery cases are sufficiently insulated so that heat is maintained for several days, even when not in use. Except for the heating requirement, the battery is totally maintenance free. The sodium sulphur battery offers a nominal energy density of 110 Wh/kg.

The key characteristics of most of the various batteries discussed above are summarized in Table 1. Shown in Table 1 are the nominal C/3 specific energy capacities of each battery together with the calculated capacity when utilized in a vehicle under different driving cycles. The C-cycle is an acceleration to 35 mph, a 20 second cruise at 35 mph and then deceleration/braking to stop. The D-cycle top speed is 45 mph for 50 seconds before deceleration/braking to stop. The 35 mph and 55 mph cases are at a constant speed. As can be seen from Table 1, the 35 mph constant speed case and the C-cycle represent the easiest duty cycle while the 55 mph constant speed case represents the most difficult. The effect of duty cycle on capacity is more pronounced with lead-acid batteries than the effect projected for the advanced battery technologies.

Table 1
Battery Characteristics

Battery Type	Specific Energy (Nominal) (Wh/kg)	Average Module Voltage (volts)	C/3 Rate (Amps)	Nominal Volumetric Energy Density (Wh/l)	Calculated Energy Capacity (Wh/kg) C-cycle	D-cycle	EV Range 55 mph (miles)	Energy Density (Wh/kg)
[illegible]	100.0	11.1	72	160	259	221	188	249	178
[illegible]	101.1	11.1	198	165	267	237	197	263	186
[illegible]	39.5	6.0	107	213	252	242	209	241	214
[illegible]	97.0	6.3	225	358	548	545	506	578	498
[illegible]	1140.0	2260	250	670	1000	1156	1116	1104	1104
[illegible]	101.1	11.1	225	267	481	428	387	459	393

[illegible] - not commercially available
[illegible] - based on battery weight of 817 kg (1800 lbs)

Auxiliary Power Unit (APU) Range Extender

The APU range extender consists of a small ICE driving an alternator. The engine runs at constant speed in two power ranges which allows for optimum tuning within those ranges. The APU output feeds into the electrical bus for distribution either to the traction motors or to the batteries to supplement battery power. In the higher power range, the alternator supplies the required additional power for air conditioner operation. The APU never produces power that is not needed.

Specifications for the ICE selected for the prototype vehicle are given in the following table:

APU Engine Specifications

Make:	Honda
Starter:	Electric/remote
Model:	GX360K1
Cooling:	Liquid cooling
Type:	2-cylinder, 4-stroke, O.H.V.
Operating Weight:	107 lb
Displacement:	359 cc (21.9 cu. in.)
Length:	20.3 in.
Maximum Horsepower:	12.2 hp @ 3600 rpm
Width:	19.3 in.
Maximum Torque:	17.3 ft.-lbf @ 3000 rpm
Height:	20.9 in.

The output of the ICE drives a UNIC high frequency 3 - phase ac alternator with a rating of 5 kW. The output of the alternator feeds a phase controlled rectifier bridge which delivers a regulated dc output to the electrical bus. The output of the bridge is both current regulated and voltage limited to prevent battery overcharging. The bridge has two regulated output levels. A 3 kW level is used for range extension when the air conditioning is off. The on/off condition of this level is manually determined by the operator. When the air conditioning is on, the 5 kW output level can be enabled. In the typical urban delivery van application it is anticipated that the auxiliary power unit need only operate about 1/2 the time.

Emission testing of the engine was conducted at the Colorado State University emissions laboratory. Figure 13 shows the prototype APU. During the testing, the ICE/alternator set was run at a

constant load of approximately 4 kW using three fuels (gasoline, LP, natural gas). The engine was equipped with a 3-way catalytic converter. The emissions test data is presented in Table 2 below.

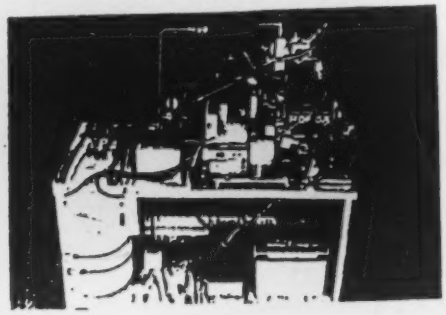

Figure 13. Prototype Auxiliary Power Unit

Table 2
Honda GX360K1
Emissions Test Data

Fuel	Gasoline	LP	CNG
HC, ppm	14	16	32
gm/hr	1.57	1.58	3.78
CO, %	0.0	0.01	.04
gm/hr	0.0	3.22	15.4
NOx, ppm	40	20	30
gm/hr	1.57	0.70	1.23
Exhaust Temp	1249°F	1210°F	1023°F
Combustion Air	17.3 scfm	15.2 scfm	18.1 scfm
Fuel Consump.	.565 gal/hr	.769 gal/hr	72 cfh

Hydrocarbon and carbon monoxide emissions were measured on a parts per million (ppm) and percent by volume basis, respectively, using a Bear Gas Analysis System 4 Analyzer. No_x emissions were measured on a ppm basis using a Horiba MEXA-240 infared gas analyzer. This volumetric emission data was used in conjunction with the measured combustion air flow to calculate the grams/hr emission values shown in the table above.

Based on the FTP 75 test cycle average running speed of approximately 21 mile/hr, and assuming the APU operates only half time, the above emission data is compared to the Federal Standard for passenger cars and California Standard for light truck/van emissions as shown in Table 3.

From the data it can be seen that the APU range extender has near zero emissions and therefore should be totally acceptable as a "bridge" to an advanced all electric system. On an equivalent total grams/mile basis, the emissions from the APU powered by LP gas will be almost 40 times less than the Federal passenger car standard and 80 times less than the current California light truck/van standards.

Table 3
Emissions Comparison
(grams/mile)

	HC	CO	NOx	Total
Federal Std (cars)	0.41	3.4	1.0	4.81
California Std (vans)	0.50	9.0	1.0	10.50
UNIQ Electric Van				
Gasoline	0.037	0.0	0.037	0.075
LP	0.038	0.077	0.017	0.131
CNG	0.09	0.367	0.029	0.486

Electric Flywheel

The electric flywheel integrates a highly efficient brushless dc motor/alternator into a state-of-the-art composite flywheel/rotor shown in Figure 14. Kinetic energy is accumulated and stored in a hermetically sealed vacuum container with only electrical inputs and outputs penetrating the container. By eliminating the shaft seal into the flywheel, the evacuated atmosphere of the sealed container can be efficiently maintained to reduce windage losses. Flywheel rotational speed (30,000 - 40,000 rpm) can be reduced to road wheel speed (0 - 1000 rpm) electrically, thus avoiding the losses of a mechanical speed reduction. Such a system is particularly beneficial in urban start-stop duty cycles because the flywheel is capable of accepting a much greater energy input from regeneration on braking than is possible with an electrochemical storage system.

The flywheel system configuration consists of the following components: a brushless dc motor/alternator (one device), the flywheel rotor and a sealed housing/bearing system. The flywheel rotor design and its interface with the motor/alternator and associated electronics is being developed in conjunction with the Mechanical Engineering Department of the University of Ottawa (Canada). The University of Ottawa program will consider several rotor designs, including the use of low cost coiled steel and higher cost filament wound composite fibers. The housing/bearing system will be designed to maintain vacuum integrity, to accommodate imposed loading (mass unbalance and gyroscopic) and to achieve safety containment in the event of a failure.

System electronics must handle the bi-directional power flow, and therefore the flywheel controller will be essentially the same as a regenerative traction motor controller. Preliminary design data indicates the power handling capability of a flywheel controller must accommodate 50 kW for short periods (30 seconds). Thus energy storage capacity will be on the order of 400 watt-hours (0.4 kWh).

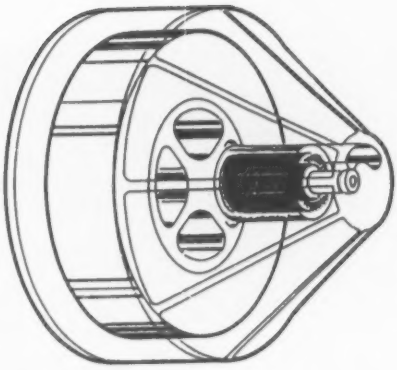

Figure 14. UNIQ® Electric Flywheel

VEHICLE PERFORMANCE

A vehicle energetics model was developed in order to analyze and project vehicle performance. The model was validated by comparing predicted results to known test data for the Unique ElecTrek and G-Van performance projections as published by Hamilton (EPRI RP2882-1, October 31, 1988). The results of such comparisons reveal the data are within ±5 percent which indicates the model can be confidently employed as a useful predictive tool.

Listed below are the key vehicle characteristics used in the simulations for the various vehicle designs in the planned development program.

Vehicle Specification and Performance Requirements:

Vehicle Description:	Prototype	Advanced	Flywheel	MPV
Vehicle Weight Analysis				
Glider Weight, lb	2671	2671	2671	1800
Electric Drivetrain, lb	850	300	400	400
Vehicle Payload, lb	870	1220	1230	750
Battery Weight, lb	1380	1380	1510	1500
Auxiliary Power, KW	3	3	Flywheel	Flywheel
Estimated APU Weight, lb	150	150	0	0
Est Fuel/Tank Weight, lb	100	100	0	0
Battery Box Weight, lb	100	100	100	0
	—	—	—	—
Gross Vehicle Weight, lb	5801	5801	5801	4250
Performance Requirements				
Acceleration 0 to 30	9 sec	9 sec	5 sec	5 sec
Vehicle Range, Miles-Cycle	100-C	100-C	150-D	>150-D
Top Speed, mph	65	65	65	70
Rolling Resistance Coeff	0.0095	0.0095	0.0095	0.0800
Tire Rolling Radius, inch	12.2	12.2	12.2	12.2
Continuous Gradeability, %	7%	7%	7%	7%
@ Speed, mph	50	50	50	60
Cd-Vehicle Drag Coeff	0.320	0.320	0.320	0.300
Vehicle Frontal Area sq-ft	28.6	28.6	28.6	26.7
Avg Traction Efficiency %	85.0%	85.0%	85.0%	85.0%
Rotary Inertia %	15.0%	12.5%	12.5%	12.5%
Motor Shaft to Wheel Ratio	3.5	7.5	7.5	6.0
Regeneration Efficiency	70.0%	70.0%	90.0%	90.0%
Battery/Flywheel Charge Efficiency	70.0%	70.0%	85.0%	85.0%
Number of Drive Motors	1	2	2	2
Ancillary Power Read (W)	300	300	800	400

The expected performance of each vehicle design is presented in detail as follows:

Prototype Vehicle

Table 4 summarizes the expected performance of the prototype vehicle based on the use of a 3 kW APU range extender.

Table 4
Prototype Vehicle Range vs. Battery Type
(3 kW Auxiliary Power Use)

	Johnson Control GC12V100	Chloride 3ET205	Sonnenschein DF80
C-cycle	109	148	115
D-cycle	45	66	49
35 mph	140	188	147
55 mph	46	69	50

Battery Weight: 1360 lbs

The data in Table 4 and also shown graphically in Figure 15 below indicate that the 100 mile C-cycle goal for the prototype vehicle is attained by using any of the three lead-acid battery types under consideration. D-cycle and 55 mph performance is less impressive because the APU range extender plays a less significant role in vehicle performance in these drive cycles

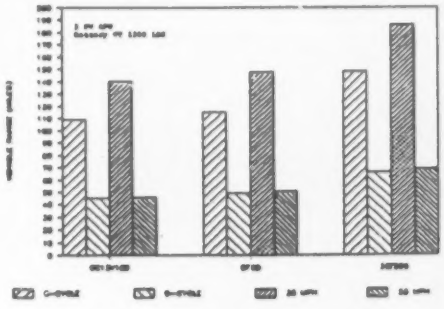

Figure 15. Prototype Vehicle Range vs. Auxiliary Power Use

Figure 16 shows the impact of the use of the APU range extender on C-cycle range. It can be seen that 100 mile C-cycle range can be achieved with the Johnson Control GC12V100 batteries by using an average of less than 3 kW from the auxiliary power unit.

With the higher specific energy of the Chloride JET205 batteries, the vehicle can achieve a 100 mile range by using less than 2.0 kW average power from the APU. Figure 16 also indicates that expected C-cycle range without the APU running equals 42 miles on the sealed GC12V100 batteries, 45 miles on the sealed DF8D batteries, and 60 miles on the wet Chloride JET205 batteries.

These figures support the contention that the use of an APU range extender is extremely attracti a as a means of increasing vehicle performance and range using current technology. Furthermore, the addition of an APU range extender allows one to consider the use of sealed "no maintenance" lead-acid batteries--a significant addition to the market appeal of the vehicle.

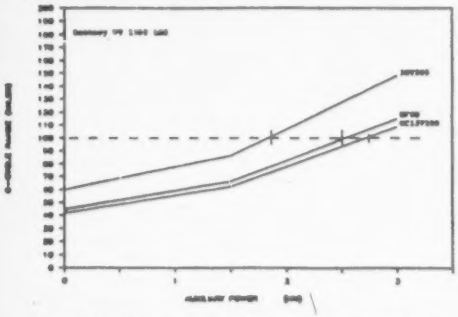

Figure 16. Prototype Vehicle C-cycle Range vs. Auxiliary Power Use

Advanced Vehicle Performance

The advanced vehicle incorporates the more efficient and lighter weight drive train. Its average traction efficiency of 85.0 percent is approximately 5 percent higher than that of the prototype vehicle. Regeneration efficiency is also higher. Figure 17 shows the C-cycle range for the advanced vehicle with three different battery options. It can be seen that the 100 mile C-cycle objective is achieved on sealed GC12V100 batteries with an average APU output of less than 2 kW. The more powerful Chloride wet batteries can realize a C-cycle range of 100 miles using only 1 kW average APU power.

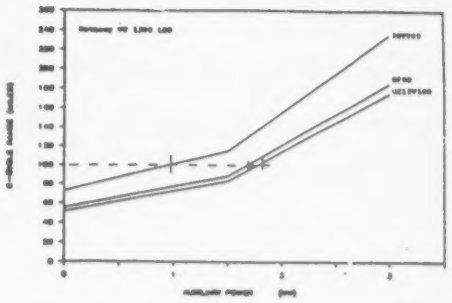

Figure 17. Advanced Vehicle C-cycle Range vs. Auxiliary Power Use

Figure 18 summarizes the advanced vehicle performance over the different operating cycles with sealed GC12V100 batteries at three different levels of auxiliary power use. Operating at the full 3 kW output available, a C-cycle range capability of 175 miles is projected.

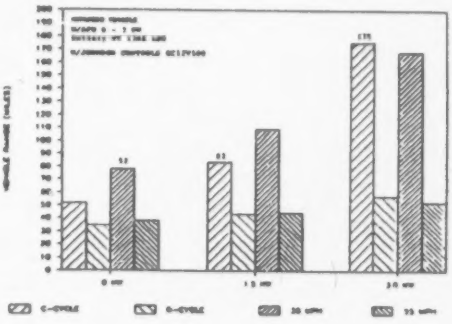

Figure 18. Advanced Vehicle Performance Using Sealed GC12V100

Performance With Advanced Batteries

Table 5 below summarizes projected vehicle performance with advanced batteries. The APU range extender is not included and for purposes of Table 5 the resultant weight savings allows battery weight to be increased to 1610 pounds. The same results are shown graphically in Figure 19 below.

Table 5
Range vs. Advanced Battery Type
(No Auxiliary Power Unit)

	Ni-Fe	NaS	Advanced Pb-Acid
C-cycle	155	325	123
D-cycle	118	256	91
35 mph	217	444	176
55 mph	137	300	109

Battery Weight 1610 lbs

Worthy of note is the fact that the 100 mile C-cycle range objective is readily achieved using either the nickel-iron battery (155 miles) or the advanced lead-acid battery. The nickel-iron battery also meets the 100 mile objective on the D-cycle (118 miles) as well as the C-cycle. The results for sodium-sulphur are even more startling. If such a battery could be produced economically and operated safely, it would have a breakthrough impact on electric vehicle development.

Also shown in Figure 19 is the impact of vehicle air conditioning (assumed 2 kW load) on vehicle performance. Range is reduced by 20-35 percent, depending on the driving cycle and batteries employed.

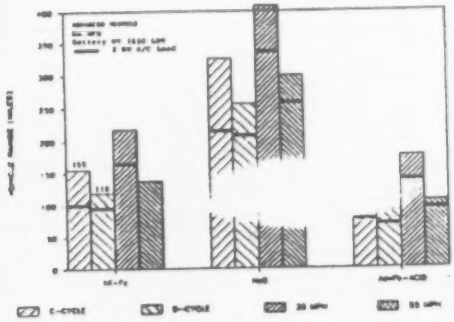

Figure 19. Advanced Vehicle Range With Advanced Batteries

Vehicle Performance With Flywheel

The flywheel option permits achievement of an acceleration objective of 0 -30 mph in 5 seconds. Batteries alone are typically not capable of achieving this rate of acceleration safely, but the required extra current and power can readily be supplied from energy stored in the flywheel. The flywheel is also much more efficient during regenerative braking inasmuch as it is capable of accepting more of the regenerated energy. The flywheel weighs approximately 100 lbs and to accommodate the extra weight, battery weight is reduced to 1510 lbs.

Figure 20 summarizes the expected performance of the vehicle with flywheel. C-cycle range is improved approximately 60 percent over the advanced battery-only vehicle. D-cycle range is only 18 percent higher. In the 35 mph and 55 mph constant speed modes, vehicle range is slightly less due to the parasitic losses of the flywheel while driving at a fixed speed.

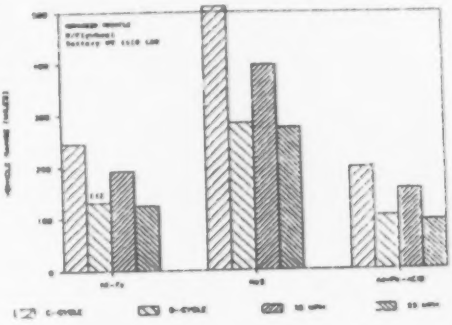

Figure 20. Advanced Vehicle Range vs. Battery Type (including Flywheel)

HPV Performance

To evaluate the performance of a multi-purpose vehicle (HPV) specifically designed for electric drive, Unique has concepted the HPV model as described above. Because of its lighter weight and a more aerodynamic shape, performance of the HPV can be significantly enhanced. Figure 21 shows the projected performance for the vehicle.

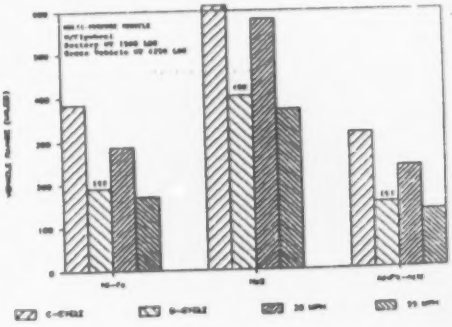

Figure 21. HPV Range vs. Battery Type (includes Flywheel)

With this advanced design, a 150 mile D-cycle range is readily achievable using only nickel-iron batteries (192 miles). Also of note is that a 153 mile range is achievable with an advanced lead acid battery. Again, the striking potential of sodium-sulphur is indicated by the projection of a 400 mile D-cycle range. Because a 400 mile range is not typically needed, the weight of the sodium sulphur battery could be reduced significantly to further enhance vehicle acceleration and top speed.

Operating Cost Comparison

To analyze operating cost, a comparison of the advanced vehicle design was made to a conventional Dodge minivan with a 6 cylinder ICE and four speed automatic transmission.

Electric and gasoline consumption figures were derived from the vehicle energetics computer model and from manufacturer's data. Fuel consumption data for the Honda APU range extender was obtained by actual test under load at the Colorado State University vehicle emission laboratory. Costs for tuning the 6 cylinder Dodge engine and the Honda APU were obtained from service managers at local dealers. For the Dodge ICE van, the cost for oil, tires and general maintenance was obtained from a sampling study of 4,888 minivan operators who were operating vehicles in an urban environment.

The general maintenance cost for the vehicle was derived from historical ElecTrak data in Unique's possession and from the minivan study. Battery costs were based on the Johnson Control Model 12v100 sealed lead-acid batterly, priced at $97 per module and $100 for each system installation or replacement. A summary of the operating costs for each vehicle, in cents per mile is listed in Table 6.

Table 6
Vehicle Operating Costs (¢ /Mile)

	UNIQ	ICE
Energy Cost:		
Gasoline	1.68	6.94
Electricity	1.10	-
Energy Total	2.78	6.94
Tuneups	0.74	1.13
Oil, Lubricants	0.24	0.35
Tires	0.73	0.58
Batteries (propulsion)	2.04	-
General Maintenance	1.83	2.15
Total ¢/mile	8.26	11.15

The data assumes gasoline at $1.25 per gallon with usage at 18 MPG. Costs for electricity were based on $0.05/kWh and a charger efficiency of 85 percent was assumed. Both vehicles were modeled to operate 80 miles/day in the urban duty C-cycle environment, 250 days per year, with retirement at 100,000 miles. It was further assumed that the battery pack would be replaced once after approximately 625 battery cycles and that at 100,000 miles both the replacement battery pack and the ICE would have zero value.

Figure 22 graphically depicts the impacts of battery life, energy costs and conventional vehicle fuel economy on the operating costs of the UNIQ vehicle in comparison with a conventional minivan when operated in an urban driving cycle.

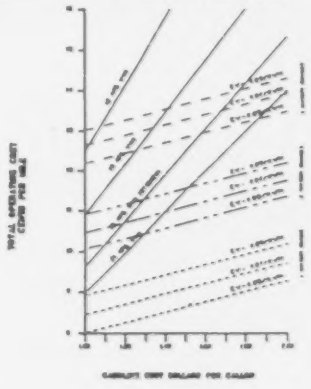

Figure 22. Operating Cost Comparison

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Mr. BROWN [presiding]. Thank you very much, Mr. Geddes.

I would like to commend all of the witnesses on this panel for presenting to the committee—the subcommittee—one of the best examples that I have seen in the Congress of effective public/private partnership in the interest of achieving national goals, something that I think our country ought to commit itself to much more strongly at the Federal level, and maybe the examples that you have given of how this works well at the local level can provide the needed inspiration for the Federal level.

Let me ask, if I can, maybe Mr. Gage or maybe Mr. Geddes, how this L.A. Initiative contract works. We have got $7 million and a contract to provide 10,000 vehicles over five years, which is about 2,000 vehicles a year. The $10 million is to provide the difference between what the vehicles will sell for and what the manufacturer can produce them for, or just what is the linkage here?

Mr. GAGE. I'm going to ask Vern Pruitt to step up here and supplement, if I may, but, in fact, Congressman, the program is designed in such a way that the first outlay of money was to help folks develop the prototypes and get ready.

We have committed $12 million over the next three years, as has our partner, Southern California Edison. Consequently, there is a pool of money to tap, as needed, as we move forward, and we haven't made any dramatic commitments yet as to how that money will be used. We are still waiting to see it evolve a bit.

Mr. PRUITT. I will be happy to add to that.

The plan for utilization of the money is to promote the early development of the prototype vehicles. The public money going into this for private development is then leveraged by the private developer to acquire additional investor funds which we will take to go beyond the prototype development into certification of the vehicles and then construction of the production/commercial vehicles to bring to market.

Mr. BROWN. Obviously, to set up a plant and an assembly line to produce even 2,000 vehicles a year is going to require some substantial capital investment. Have you looked at all of this picture to see how much capital investment and what the private market will provide and so forth?

Mr. GEDDES. Mr. Brown, speaking for Unique Mobility and our participation in this program, as we understand it, as Mr. Gage and Mr. Pruitt have mentioned that the money that is available now is to design, engineer, and get ready for production.

From our standpoint, our commitment to this program, which is supported by our technology partner, Alcan Aluminium, is to supply the capital to go into production once we have done the engineering job and certified the vehicle.

Mr. BROWN. Okay.

Mr. GEDDES. And we are prepared to do that.

Mr. BROWN. Then, can you produce a vehicle that you can market at a profitable level?

Mr. GEDDES. We cannot market the vehicle without some incentive, because I think a good rule of thumb for these types of vehicles is that if you produce them in quantities of say, hundreds, the cost of the vehicle can be three to four times as much as the conventional counterpart. If you produce them in quantities of thou-

sands, you might get down to double the cost of its conventional counterpart.

So the production level has got to get up beyond the 10,000 units, I think, that are contemplated in the L.A. Initiative, before these incentives can go away in its entirety. Of course, part of that will help, or will be helped considerably by legislative actions. There are actions going on right now, I think, as we speak, in California to enact some legislation that will further encourage, if not mandate, these vehicles to come into production under certain circumstances, and I think there are some customers for these vehicles who will step up and pay premium prices for them.

Some comment was made before by Mr. Davis about the DOE program for the users task force. Well, the chairman of the users task force is a member of our board of directors, Mr. Cliff Hayden. Cliff Hayden is the manager of fleet and energy for GTE Corporation. As such, he is responsible for the largest privately owned fleet of vehicles in the country. I think he has over 50,000 vehicles in his fleet.

I can't speak for GTE, but I can speak for the fact that there is considerable indication of interest in a fleet of that size—particularly, a lot of those vehicles operate in Southern California—that they would be willing to go to almost any length to be able to acquire a reasonably priced electric vehicle even if it had some premium costs associated with it.

Mr. GAGE. If I might supplement, Congressman, the South Coast Air Quality Management is interested in working with us to develop some additional incentives for those electric vehicles brought on earlier than their otherwise '98 time frame. Consequently, we think that those incentives will also add to the attractiveness of this vehicle.

Mr. BROWN. Well, the thrust of my questions, obviously, is to see how all of these things fit together so that we can have a workable program that will achieve the goals here. I want to see us move beyond 10,000 vehicles as quickly as possible. I want to see how the $10 million per year, or whatever we can get through in Federal legislation, fits into this, and then, of course, I'm expecting the South Coast Air District to provide some additional incentives also. Now whether that is in the form of cash or regulatory type of thing it's not clear in my mind, and since I obviously will get a lot of questions about this sort of thing and I need to make inspirational speeches, I want to see how all the pieces fit together so that we can push this to the maximum.

What can the Air Pollution District do to give us a little extra push here?

Mr. GAGE. It won't be cash incentives, Congressman. Regulatory relief.

Mr. BROWN. Yes. Well, regulatory relief could be significant.

Mr. GAGE. Yes, sir.

Mr. BROWN. Of course, the kind I'd really like to see is Federal regulation that would provide some very strong incentives to include electric vehicles in the major fleet of the major automotive manufacturers.

Mr. TORRICELLI. Mr. Brown, you have concluded?

Mr. BROWN. For the time being.

Mr. TORRICELLI. Mr. Gage, I missed some of the exchange that you had, but forgive me if I'm covering something previously discussed, but why, in your judgment, have the three principal automobile manufacturers in the United States not bid on these vehicles? What explanation do you receive from them, if any?

Mr. GAGE. I'm not sure that I can adequately describe their motives for not participating. I think, Mr. Chairman, that they are more adequate at that than I. I, frankly, would like to see a more innovative side and a more risk-taking side from American industry generally and the auto makers in particular in this instance, but, nonetheless, we have some small, innovative companies that are willing to take the risk and work with us to try to develop this initiative. I think that those folks will, in fact, provide the incentive for the Big Three to move a little more quickly than they otherwise would have.

Mr. TORRICELLI. And from this experience, are you convinced that there is an entrepreneurial team out there that is prepared to fill the vacuum if the Big Three do not?

Mr. GAGE. I am convinced of it, Mr. Chairman. Both in the U.S. and certainly larger firms in Europe, in the form of Fiat and Peugeot, are already actively developing electric vehicles. So I think—

Mr. TORRICELLI. Some of us consider that a mixed blessing as an answer to the problem.

Mr. GAGE. As would I.

Mr. TORRICELLI. For any member of the panel, is there a role for the utility companies themselves, beyond in planning for infrastructure and basic technology, to become partners or venturers in vehicle production, recognizing the regulatory obstacles of doing so?

Mr. STEINKE. I think at this point, Mr. Chairman, we are supporting the technology as best we can and the development. I think we are looking more beyond that though. We will continue to support it as best we can, but, beyond that, the marketplace has to be developed out there. We will serve our customers. We have a lot of customers in New Jersey, and we will serve them well, but I think our research programs—we have had a Best facility—that is, a battery energy test facility—that operated for 10 years with EPRI to develop batteries, and working along with that.

Mr. TORRICELLI. There is a chicken and egg aspect of this, though, which comes right back to the utilities on infrastructure. In particular, talking about our own area of the world, Mr. Steinke, this is of great value, I believe, for second and third automobiles for home owners in suburban areas—

Mr. STEINKE. Exactly.

Mr. TORRICELLI. —but will never be more than that if they cannot be assured range. We can wait for a currently unforeseen breakthrough in technology or provide an infrastructure that yields the same result.

So, for example, is the appropriate role for utilities today to be voluntarily planning for things—for example, refueling stops along the turnpike or the parkway—or should this be something that Government is commanding or planning?

Mr. STEINKE. I think, infrastructure-wise, we are ready right now. Our utility, we have 10,000 megawatts of capacity for our

peak, but off peak, every night, we run about 3,000 megawatts, so there's 6,000 to 7,000 megawatts of energy capacity that isn't being utilized.

Mr. TORRICELLI. So how many automobiles, for example, could be recharging in the State now? The number cited for California was a million, I think?

Mr. STEINKE. We could handle a million to a million and a half without any problem.

Mr. TORRICELLI. Without any capacity problems?

Mr. STEINKE. No capacity problems. We would not need one dollar of O&M expenses, and, in fact, our capacity would run better at night and be more efficient and would provide the customer instant savings—to our regular electric customers.

Mr. TORRICELLI. Now why not take the extremely bold move ahead of Government and ahead of the industry and provide an infrastructure immediately to potential users so that you could announce in 1991 that at refueling stops along the State's principal highways, where you already maintain power lines, there's going to be a little booth set up in each corner where a person can dial in their PSE&G account number and plug their car in while they go get a cup of coffee in a rest stop?

Mr. STEINKE. We would rather do that in their home. It takes a little longer to charge it up than a rest stop. The technology today is not that simple to charge it up in 15 or 20 minutes. But in their home, an average housewife can pull in her garage and plug it in, and today that infrastructure, that technology, is available, and it would be no problem. We could price it perhaps at 50 cents a gallon on night rate.

Mr. TORRICELLI. I'm going to come back to my example, but I'll play with yours for a moment.

So, for example, the marketing of the kind of charge equipment that would be necessary—

Mr. STEINKE. We would like to be involved in it.

Mr. TORRICELLI. —and setting it up, that you could begin promoting in your bills, for example, to create an atmosphere and a public consciousness of this as an option is something the company could do now. However, in some of these stations as well—this will get into some of the battery technology, but I assume that while they require a long deep charge for full operations, if they are like any other battery—and they may not be—that I'm aware of, you can, nevertheless, give a boost of power in short periods of time by giving high insertion of power fast.

Mr. STEINKE. From a technology point of view, I don't think that would be most efficient for the vehicle.

Mr. TORRICELLI. No, it may not, but, nevertheless, if you are 100 miles from home and you are slowing down, it's the better of the two options.

Mr. STEINKE. That's correct.

Mr. BROWN. Would the gentleman yield briefly to me?

Mr. TORRICELLI. Yes.

Mr. BROWN. More or less along this same line, have you tried to calculate the savings that would accrue to the utility from the load balancing aspects of this under different conditions—that is, utilizing your off-peak load? And a follow-on to that would be, could you

use any of this savings to justify the utility's own investment in the fleet of electric vehicles so that you could begin to promote this economy from load balancing as well as promote the vehicle concept itself?

Mr. STEINKE. I'll speak to that.

Bob, would you like to—

Mr. DIETCH. I'll just comment on one thing. Speaking of looking at infrastructure and looking at how to make this work, one of the things that we had looked at in that regard was that the off peak would be used and, instead, any savings would be used to give the super rate to the customer in order to try and subsidize in that way, that the customer would, in fact, go for electric vehicles.

Mr. BROWN. That's a very reasonable way to approach it. I certainly would approve of that. But I also want to see more vehicles moving in, and if part of that savings could be used in addition to subsidizing the rate, subsidizing your purchasing more vehicles, there would be values from that also.

Mr. DIETCH. Oh, yes. We would intend to be one of the fleet purchasers as well, to be investing in it.

Mr. STEINKE. One key point to that is that we are regulated utilities and that the Board of Public Utility Commission in New Jersey regulates our rates, so we are not quite free to change rates around at will, but we can make recommendations and then we have to work with them. So it would depend upon how these savings are passed back.

Mr. BROWN. We would assume that any major initiative of this sort would require a little cooperation from rate regulatory agencies.

Mr. TORRICELLI. Let me ask in that vein, if I could, if you made the very modest step, one, of marketing charging equipment and encouraging its sales through your billing process; (b) made the somewhat bolder step of actually, in your rate base, paying for and installing charging equipment in public places around the States; and, three, made the phenomenally bold move of actually marketing and electric vehicle—now, if you did (a), (b), or (c), in your judgment, would the State regulatory agencies allow you to do any or clearly prohibit you from doing any of those in the current mode of thinking?

Mr. STEINKE. We would have to do a lot of work with them.

Mr. TORRICELLI. For any of them?

Mr. STEINKE. The first one might be more doable. The equipment, the charging equipment, might be more doable.

Mr. DIETCH. The marketing of electric vehicles would be less doable, I believe, of the three.

Mr. STEINKE. Yes.

Mr. DIETCH. There is another part of the infrastructure and another part that utilities could be involved in, and that's the batteries alone.

Mr. STEINKE. Yes.

Mr. DIETCH. To either be a supplier—

Mr. TORRICELLI. This kind of Swiss system that we saw?

Mr. DIETCH. Supplier or lessor of batteries and just billing through their regular electric billing process.

Mr. STEINKE. Yes, that would be good.

Mr. DIETCH. Automobile manufacturers like that.

Mr. TORRICELLI. This, of course, is an alternative to my thought about putting the power boost stations along the highways as well, that there be PSE&G, in our case, little stands next to the Exxon station where you switch batteries for the trip home.

Mr. STEINKE. If the technology comes that far, we would be more than happy to do that, I think.

Mr. TORRICELLI. In your conversations, though, and experiences with the State regulatory agencies, do you see or sense any creative thinking going on where they are prepared to start hearing these ideas from you?

Mr. STEINKE. In New Jersey, there's a trend towards that, although we have not explored the electric vehicle issue with them yet, but there is a trend to be more creative in their approach. In California, I don't know what they have.

Mr. DIETCH. It's the best I can say, and in a research arena, in seeking out research dollars for electric vehicles, they have been very amenable to that, much more so than in the past.

Mr. TORRICELLI. We have talked here today about changing the automobile fleet gasoline standards as an incentive. Otherwise, we have just talked about continued emphasis on the Federal Government playing a role in funding the battery research. Is there anything else specifically that you can see that you would like to see us do that appeals to you in particular as a Federal initiative to help at this point?

Mr. DIETCH. I would name only one right off the top of my head, and that is, the Federal fleets would also be a good target for electric vehicles.

Mr. TORRICELLI. You mean Federal purchase itself as a subsidy.

Mr. DIETCH. Federal purchase itself.

Mr. TORRICELLI. Anything else?

Mr. STEINKE. I would agree with that.

Mr. GAGE. A couple of thoughts. One might be an emissions tax at the pump that obviously would have some very positive effects. The other might be that you encourage your Department of Energy to bring to market, if you will, more quickly a product. We in the United States tend to have the best reputation for research and development and one of the worse for bringing it to market, and I think we've spent a lot of money in electric vehicle research over the last couple of decades and we haven't gotten much to market.

Mr. TORRICELLI. In all deference to our colleagues who are not here from the other side, were it my Department of Energy it would be brought to market; it isn't.

Mr. DIETCH. Just one more comment. There was nothing more telling than the ABC video that you showed, that the next decade should be the time—the next decade.

I run a research operation as well as other things in the company, and one of the most difficult things is to pull it out of research, roll it over, get it on the market. They will research it to death.

Mr. TORRICELLI. Gentlemen, Thank you very much.

As we look into the next Congress, and Mr. Brown's legislation, and how to contribute to it, some of the comments you offer here today will be very helpful. I hope as you get continuing ideas you

will share them with the committee in correspondence or visit. We would really welcome the continued benefit of your thoughts.

Thank you very much.

For our third and final panel, if we could, please: John Wallace, director, Electronic Systems Research Laboratory, Ford Motor Company; Robert Davis, executive engineer, Special Projects Engineering, Chrysler Corporation; John Zwerner, executive director of advanced project engineering, the General Motors Corporation.

STATEMENTS OF JOHN WALLACE, DIRECTOR, ELECTRONIC SYSTEMS RESEARCH LABORATORY, FORD MOTOR COMPANY; ROBERT L. DAVIS, EXECUTIVE ENGINEER, SPECIAL PROJECTS ENGINEERING, CHRYSLER CORPORATION; AND JOHN S. ZWERNER, EXECUTIVE DIRECTOR, ADVANCED PROJECT ENGINEERING, GENERAL MOTORS CORPORATION

Mr. WALLACE. Mr. Chairman, my name is John Wallace, and I'm the director of Ford's Electric Systems Research—

Mr. TORRICELLI. Mr. Wallace, if I could, just for a moment, I have a great fear about, because of activities on the Floor, that we are going to be interrupted for a significant number of votes later. So, in advance, I will apologize to you. There are obviously some specific questions that I, at least, would like to ask, and I, depending on the votes, expect some Members from the minority and majority to want to do so as well. Let me just ask, because we will be able to read all of your testimonies in the privacy of our offices, to try to save as much time so we do not get interrupted.

I apologize for that. I would not have it be so, but it is a reality, and I know you have been very patient about waiting and very generous with your time in being here today, for which I am very appreciative, but let's try to conserve time as best we can so we can talk before we are inevitably pulled apart.

Mr. Wallace, welcome, and thank you very much for being here today.

Mr. WALLACE. I will paraphrase my written comments then in order to save some time.

Basically, Ford has been actively involved in the development of electric vehicle technologies over the last 10 years, primarily in partnership with the Department of Energy. We have had a program with the DOE and General Electric to develop various electric vehicle technologies that has culminated in the delivery of the ETX-II Aerostar that you saw in the film on "Prime Time Live." Basically, this vehicle is very close to customer-acceptable performance with a 65-mile-per-hour top speed, 100-mile driving range, and acceleration in less than 20 seconds.

Currently, we are faced with an environment in which emissions regulations and concerns about energy independence have increased the interest in electric vehicles as production vehicles. Ford Motor has—in reflecting that interest, has increased its program internally to develop this technology and has begun to move it out of the research area and into a program management area. We anticipate that we will be spending tens of millions of dollars over the next few years to advance this technology to produce a customer-acceptable vehicle for production.

There are some major issues still left with electric vehicles and the current state of technology. I don't think these should be overlooked. Perhaps the most critical issue is driving range. The range of electric vehicles is approximately limited to about 100 miles today. This is a fairly serious issue, especially coupled with the long refueling times that are inherent in the current battery technology, six hours or more for a full recharge and two to three hours for a partial recharge. With the current vehicle, you can completely refuel your fuel tank in a matter of minutes basically allowing internal combustion engines an unlimited range.

Thirdly, performance of electric vehicles, with some notable exceptions, is somewhat limited. We are limited in both acceleration and top speed, and we have made a lot of progress on this, and we anticipate that in the future we will be able to remove this constraint.

Packaging is also an issue. Batteries now are very large and very heavy. They subtract from the payload capability of our vehicles, something that is of great concern to our commercial customers, and they make it very difficult to actually fit the batteries within the space of the vehicles, especially as vehicles become smaller.

Although we have talked about operating costs and have compared cost of electricity to the cost of gasoline, the true costs of operating an electric vehicle is primarily contributed by amortization of the batteries; that is, batteries wear out; and because batteries are a very expensive part of the vehicle, the operating cost of these replacement batteries dominates the cost of electricity. Until we can get cheaper or longer-lived batteries, electric vehicles will be more expensive to operate than their corresponding internal combustion engine counterparts.

Basically, when we go out to the marketplace and attempt to sell electric vehicles to our customers, we have to have these vehicles compete head-to-head on the showroom floor with internal combustion engine vehicles. Until we can offer our customers an electric vehicle that is successful at that competition, it is not clear to us how we are going to be able to sell significant numbers of these vehicles.

Most of our work internally now is devoted to improving our power trains, improving the vehicle technology, and attempting to meet our customer requirements.

One of the areas that we wish to comment on with H.R. 3852 is to suggest that a good use of the Government's funds and assistance would be in developing improved battery technology. This is the key technology that determines the acceptance of electric vehicles today. Lead-acid battery vehicles are limited in their capabilities, and we would really appreciate a much better battery. This would help us a lot in these areas of range, performance, and package-ability.

The development of these better batteries will take considerable time and considerable funds. As an example, it is reputed that Asea Brown Boveri, who is the developer of the advanced sodium sulphur battery, has spent over a quarter-billion dollars in internal funding to try to bring that battery to market and it is still not ready for production. These are non-negligible difficulties from a technical point of view.

In general, I think that we support the efforts of the Federal Government. We are a partner with the Federal Government currently in the development of electric vehicle technology. We welcome the active assistance and participation of both the Federal and the State Governments in developing this technology, and I think we are primarily interested in applying those funds where it can do us the most good.

Thank you.

[The prepared statement of Mr. Wallace follows:]

Statement of John R. Wallace
Director, Electronic Systems Research Laboratory
Ford Motor Company
Before the House Science, Space and Technology
Subcommittee on Transportation, Aviation and Materials
September 25, 1990

Mr. Chairman, my name is John Wallace, director of Ford's Electronic Systems Research Laboratory. Ford appreciates the opportunity to appear before this committee and review the status of our electric vehicle development. In addition, I would like to share our views on the role electric vehicles could play in the nation's transportation system.

Ford has been actively involved in the development of electric vehicle technologies for more than ten years. Since 1982, we have been a major participant in a joint venture with the U.S. Department of Energy, General Electric and several battery manufacturers. The first phase of this program focused on developing an integrated motor and transaxle on the same drive axle, which eliminated many of the disadvantages of previous electric vehicle designs. The second phase established further technical feasibility of this design and resolved some of the remaining technical problems. The culmination of this phase was the ETX-II Aerostar van, an electric test-bed vehicle that is powered by a sodium-sulphur battery. It operates at speeds up to 65 miles-per-hour (mph), provides a 100-mile driving range and accelerates from 0 to 50 mph in less than 20 seconds. While these results are promising, there are a number of technical obstacles that must be overcome before electric vehicles can be acceptable in the marketplace.

Concerns about ozone nonattainment in some areas of the country and the singular reliance on petroleum products as motor vehicle fuels has sparked renewed interest in electric vehicles. Electric vehicles should be capable of meeting the emission reduction goals for fleet vehicles being proposed in legislation now before Congress and proposed California regulations. However, market demand for electric vehicles is largely dependent on reducing the substantial cost penalty of these vehicles versus conventionally powered

vehicles, increasing the driving range and vehicle performance to acceptable levels and reducing battery recharge time.

Ford believes that electric vehicles have a role to play in the future, and we plan to continue our research and engineering efforts and to develop an improved understanding of the market's reaction to electric vehicles. Among the approaches under consideration is a small demonstration fleet of vehicles, which could be used as a means to gather field experience with this technology.

Our market research indicates that consumers are interested in the environmental and energy diversification benefits that electric vehicles could provide, but they have concerns with electric vehicle technology, including:

Driving Range. Today, a typical gasoline-powered vehicle equipped with a 15 gallon fuel tank has a driving range of about 375 miles. By comparison, the driving range of an electric vehicle is limited to about 100 miles -- less than one-third the distance a conventionally fueled vehicle could travel before refueling is required.

Refueling. In addition to more frequent refueling requirements, the amount of time it takes to recharge an electric vehicle is significantly greater than the time required to refill a gasoline tank. Presently, about eight hours are required to recharge vehicle batteries whereas most gasoline tanks can be refilled in less than five minutes. We also believe that convenient availability of battery recharging facilities will be important to consumers.

Performance. Until recently, 40 mph was the top speed of most electric vehicles. This may be adequate for congested traffic situations such as the rush hour stop-and-go conditions that occur in the downtown area of many cities, but today's motorists want and need vehicles that have acceleration and top-speed characteristics suitable for free-flowing traffic conditions in city and highway driving. While the ETX-II easily reaches a top speed of 65 mph, higher operating speeds rapidly wear the

batteries down -- leading to the need for more frequent recharging.

Packaging. Presently, batteries used to power electric motor vehicles are quite large and very heavy. Major vehicle redesign would be required to accommodate batteries and to provide power sources for vehicle accessories such as air conditioning, heating and power steering.

Operating Cost. Although the energy costs per mile of operating electric vehicles are less than that of gasoline, batteries have a limited useful life. Present technology batteries can only be recharged about 500 times -- for a maximum useful life of about 30,000 miles -- before they must be replaced. The initial cost of the batteries (and replacements) is expected to raise the total cost of ownership above that of conventionally fueled vehicles.

In addition to resolving issues concerning vehicle operation, the full impact of widespread use of electric vehicles -- including the amount of electric generating capacity required and the increased powerplant emissions that would result -- need to be evaluated.

The committee asked for our comments on H.R.3852, the Electric Vehicle Technology Development and Demonstration Act of 1990. Ford supports government initiatives that would help accelerate the development and demonstration of electric vehicle technology. By providing reimbursements to manufacturers and incentives to buyers, H.R.3852 would be an appropriate way to help stimulate manufacturers' interest in building these vehicles and overcome consumer reluctance to purchase new technologies. However, we believe that the proposed timing of such incentives is premature, given the present state of electric vehicle technology development. We also are concerned that if too many electric vehicles are put in service before the technology is sufficiently developed, it could potentially impede long-term market acceptance of these vehicles.

Clearly, there is an important role that government can play to help speed

development of electric-vehicle technology and make it more attractive for commercial or personal transportation. In this regard, we believe that government funds would be more effectively utilized if directed toward perfecting battery technology, which is the critical element of any electric vehicle program. The availability of viable battery technology would help to assure that all motor vehicle manufacturers would have the opportunity to develop electric vehicles and compete in this market.

It is also important that battery development funding be earmarked for research and development over an extended period of time -- perhaps as long as ten years. Although breakthroughs in technology are always possible, history has shown that improvements in battery technology are more likely to occur in small increments over longer periods of time.

This concludes my prepared testimony. I would be happy to answer any questions that you might have.

Mr. TORRICELLI. Thank you very much, Mr. Wallace.

Mr. Davis.

Mr. ROBERT DAVIS. Thank you, and good afternoon.

I am Robert Davis, executive engineer in the Special Projects Engineering Office for Chrysler Corporation. Chrysler appreciates the opportunity to express our views concerning our development experience and the future potential of electric vehicles.

As concerns deepen over our country's energy consumption patterns and increased dependence upon foreign oil, there is a need to explore alternatives to gasoline power plants for motor vehicles. In this regard, Chrysler has active programs in place to explore a variety of alternate fuels, including methanol, ethanol, compressed natural gas, and electric vehicles.

The advantages of electric vehicles, if they could be developed to compete in performance with gasoline-powered vehicles, are well known. Traditional tail pipe and evaporative emissions from electric vehicles would be zero. The key question, of course, is, can electrics be developed to compete in any usage regime with gasoline-powered vehicles? That is the question that we and others are trying to answer.

Chrysler has been involved with electric vehicles since the delivery of an electric-powered, four-passenger car in the late 1970's under a DOE-GE contract. A Chrysler subsidiary, Pentastar Electronics, is completing a four-year contract with the Electric Power Research Institute and is scheduled to complete the building of four electric-powered TE minivans within the next several months.

The TEVan is shown in the attachment, is an electric-powered conversion of Chrysler's minivan. It has a DC traction motor, automatic transmission, electric-power-assisted steering and brakes, a diesel-fueled heater, electric power air conditioning, and a nickel-iron battery pack. The exterior and interior are similar to the normal minivan. The conversion to electric power adds over 2,000 pounds to the weight, of which 1,800 pounds is in the battery pack and tray.

The TEVans should be considered concept vehicles, as the first one has less than 500 miles of test and evaluation. No attempts have been made to impact test these vehicles, but we expect that this added weight will require a substantial development effort to meet impact test requirements.

The main problems we see at this time preventing electric vehicles from becoming a commercial success are: battery development, initial cost, and limited range. We believe it would be possible for Chrysler to build an electric vehicle without the battery for a cost similar to that of a gasoline engine vehicle. This, of course, assumes our suppliers would be facilitized, which they are not, to mass produce the major electrical components of an electric vehicle.

The preliminary prices we have been quoted by one potential source for the nickel-iron battery is in excess of $6,000, and that is based on their being mass produced. That would place the initial retail cost of the vehicle between 35 and 50 percent higher than a comparable gasoline engine vehicle. As you can see, the battery will be the major component in determining the cost penalty of the vehicle.

Today's gasoline vehicles have a virtually unlimited range, as they can be refueled in about five minutes at facilities readily available everywhere compared to an eight-hour recharge for the TEVan.

The TEVan has a range of 120 miles on the SAE cycle. To put this range in perspective, we could get you from this building to Dulles Airport but probably couldn't get you back. The limited range also becomes an issue for the utilities as projections for generating capacity, improvements in air pollution, and customer operating costs are based on off-peak charging.

Several problems which concern us with the nickel-iron batteries are: number one, they emit a hydrogen gas, which is a safety concern: and, secondly, they require the addition of a lot of water, up to seven and a half gallons of deionized water per week, which we feel would be a measurable customer inconvenience.

To continue to address the full range of electric vehicle technical challenges, Chrysler is proceeding on a test and development program for the TEVan. We are presently discussing another joint program with the Electric Power Research Institute for the next phase of development, which would produce 30 vehicles for field testing in the 1994 time frame. In addition to this vehicle development, we envision many infrastructural changes for electric vehicles to support their being charged at homes, offices, and parking lots.

Waste disposal, especially for the batteries, is another problem which must be addressed. With our present state of knowledge, and particularly the status of battery development, we project that electric vehicles might, at best, eventually compete with gasoline-powered vehicles in limited, central controlled, fleet applications.

Finally, Mr. Chairman, a comment on House Rule 3852. Chrysler believes that any further funding devoted to electric-powered vehicles could be more effectively applied to research on battery technology. A breakthrough in battery technology is the real key to success.

This concludes my written preparation and testimony, and I'd be happy to handle any questions at this time.

[The prepared statement of Mr. Robert Davis follows:]

STATEMENT OF ROBERT L. DAVIS

Executive Engineer - Special Projects Engineering Office
Chrysler Corporation
Before the House Committee on Science, Space and Technology
Subcommittee on Transportation, Aviation and Materials
September 25, 1990

CHRYSLER ELECTRIC VEHICLE PROGRAMS

Thank you and good afternoon. I am Robert Davis, Executive Engineer in the Special Projects Engineering Office for Chrysler Corporation.

Chrysler appreciates the opportunity to express our views concerning our development experience and the future potential of electric vehicles. As concerns deepen over our country's energy consumption patterns and increased dependence on foreign oil, there is a need to explore alternatives to gasoline powerplants for motor vehicles. In this regard, Chrysler has active programs in place to explore a variety of alternative fuels, including methanol, ethanol, compressed natural gas and electric vehicles.

The advantages of electric vehicles, if they could be developed to compete in performance with gasoline-powered vehicles, are well known. Traditional tailpipe and evaporative emissions from electrics would be zero. The key question, of course, is can electrics be developed to compete in any usage regime with gasoline-powered vehicles. That is the question we and others are trying to answer.

Chrysler has been involved with electric vehicles since the delivery of an electric-powered 4-passenger car in the late 1970s under a DOE/GE Contract. A Chrysler subsidiary, Pentastar Electronics, is completing a 4-year contract with the Electric Power Research Institute (EPRI) and is scheduled to complete the build of four electric-powered TEVan minivans within the next several months. The TEVan, as shown in the attachment, is an electric-powered conversion of Chrysler's minivan. It has a DC traction motor, automatic transmission, electric power assisted steering and brakes, a diesel-fueled heater, electric power air conditioning, and a nickel-iron battery pack. The exterior and interior are similar to a normal minivan. The conversion to electric-power adds over 2000 lbs. to the weight, of which 1800 lbs. is in the battery pack and tray. These TEVans should be considered concept vehicles as the first one has less than 500 miles of test and evaluation. No attempts have been made to impact test these vehicles, but we expect that this added weight will require a substantial development effort in order to meet the impact test requirements. The main problems we see at this time preventing electric vehicles from becoming a commercial success are:

1. Battery development
2. Initial cost
3. Limited range

We believe it would be possible for Chrysler to build an electric vehicle without the battery for a cost similar to that of a gasoline-engine vehicle. This, of course, assumes that the suppliers would be facilitized (which they are not) to mass produce the major electrical components of an electric vehicle. The preliminary price we have been quoted by one potential source for the nickel-iron batteries is in excess of $6,000. And that is based on their being mass-produced. That would place the initial retail cost of the vehicle between 35 and 50% higher than that of a comparable gasoline-engine vehicle. As you can see, the battery will be the major component in determining the cost penalty of the vehicle.

Today's gasoline-powered vehicles have virtually an unlimited range, as they can be re-fueled in about 5 minutes at facilities readily available everywhere, compared to an 8-hour recharge for the TEVan. The TEVan has a range of 120 miles (SAE C-Cycle range). To put this range in perspective, at highway speed with the air conditioning on, we could go from this building to Dulles Airport -- but I am not so sure we could get you back again. Limited range also becomes an issue for the utilities, as projections for generation capacity, improvements in air pollution and customer operating costs are based on off-peak recharging.

Several problems which concern us with nickel-iron batteries are:

1. They emit hydrogen gas which is a safety concern.

2. They require the addition of a lot of water -- up to 7 1/2 gallons of deionized water per week, which we feel would be a measurable customer inconvenience.

To continue to address the full range of electric vehicle technical challenges, Chrysler is proceeding on a test and development program for the TEVan. We are presently discussing another joint program with EPRI for the next phase of development which would produce 30 vehicles for field testing in the 1994 time frame.

In addition to this vehicle development, we envision many infrastructural changes for electric vehicles to support their being charged at homes, offices and parking lots. Waste disposal, especially for batteries, is another problem that must be addressed.

With our present state of knowledge and, particularly the status of battery development, we project that electric vehicles might, at best, eventually compete with gasoline-powered vehicles in limited, centrally-controlled fleet applications.

Finally, Mr. Chairman, a comment on H.R. 3852. Chrysler believes that any further funding devoted to electric-powered vehicles could more effectively be applied to research on battery technology. A breakthrough in battery technology is the real key to success.

* * *

ELECTRIC VEHICLE PROGRAM

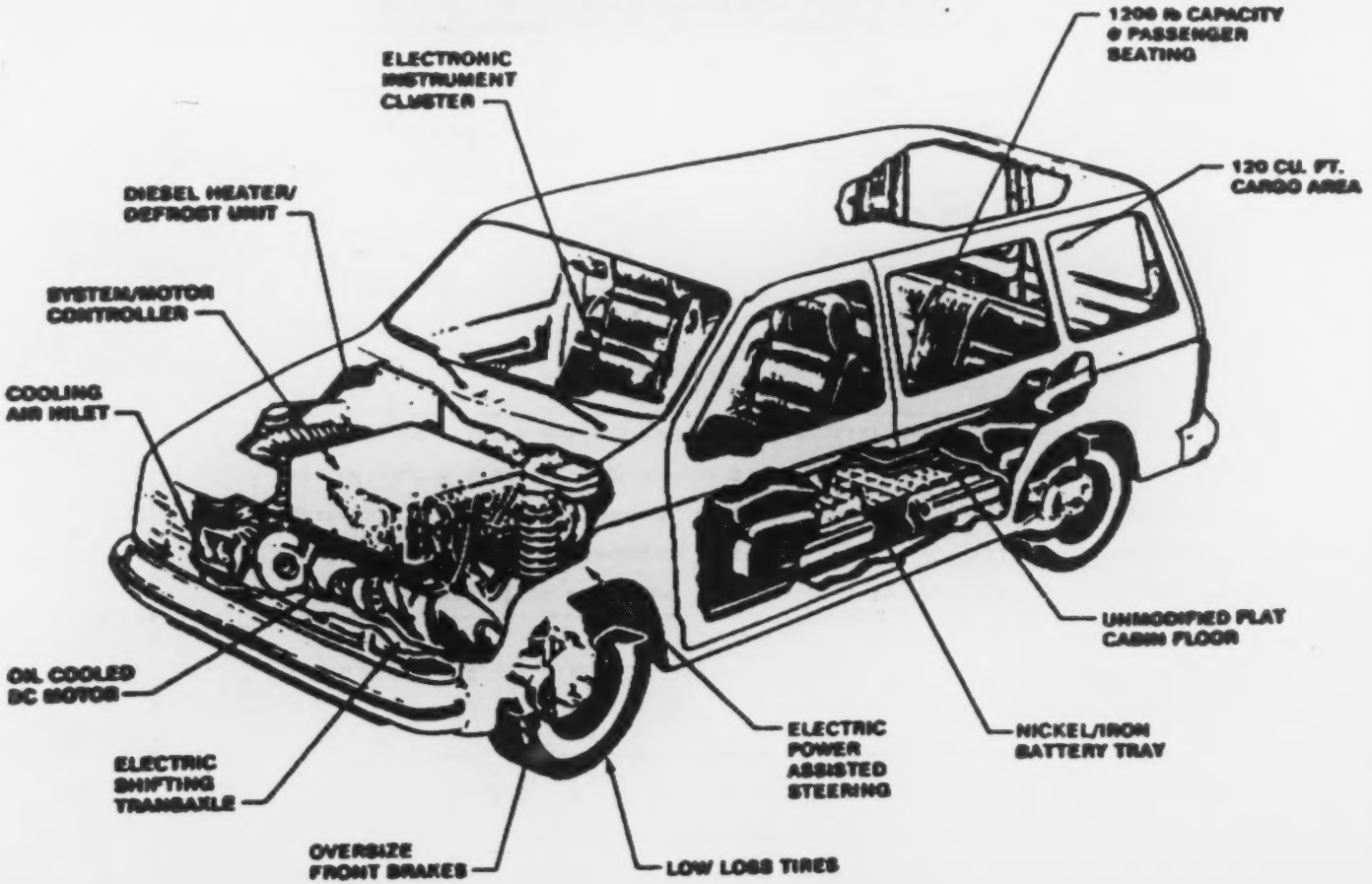
VEHICLE DESCRIPTION:

The TEVan (Phase I) is a concept vehicle built by Pentastar Electronics, Inc.* for the Electric Power Research Institute. It is a T-115 SWB modified to accomodate storage batteries and an electrical drive system. It uses Nickel Iron batteries from Eagle-Picher, a D.C. drive system specified by P.E.I. and built by G.E., and a motor / vehicle controller designed and built by P.E.I.

	T-115 Actual	TEVan Target	GM G - Van
Powertrain	2.5L 3 Spd ATXL	D.C. Motor 2 Spd MTXL	D.C. Motor Fixed Gear
Fuel (energy)	Gasoline	Ni/Fe Battery	Lead/Acid Battery
Battery Life	- - -	> 100,000 Mi.	25,000 Mi.
Test Weight	3750 #	5750 #	7800 #
Range, miles			
SAE C Cycle	> 300	120 [118 actual]	54
FUDS Cycle	> 300	90 [projected]	40
Acceleration, secs.			
0 - 30 MPH	6	7 [<9 actual]	13
0 - 60 MPH	18	25 [>25 actual]	- - -
Top Speed, MPH	> 90	70	53
Payload	7 Pass + 150 # [or 1200 # tot.]	5 Pass + 125 # [or 875 # tot.]	8 Pass + 600 # [or 1600 # tot.]

* A subsidiary of Chrysler Corporation

THE TEVan CONCEPT



Mr. TORRICELLI. Thank you, Mr. Davis, very much.

Mr. Zwerner, I'm going to miss this vote; it is nothing of consequence; but one is going to follow it relatively soon. I'd appreciate, because I would very much—so you don't have to remain after a series of votes either—if you could conclude your testimony in some brief order, so we can get 10 or 15 minutes of questions in.

Mr. ZWERNER. Certainly.

Mr. TORRICELLI. It would be very helpful to me. I have a list of things I've waited all afternoon to ask each of you. I'd just like to do so briefly, if I could.

Please proceed.

Mr. ZWERNER. Fine. My name is John Zwerner. I'm executive director of advanced product engineering for General Motors Corporation. General Motors appreciates this opportunity to discuss electric vehicle technology with this subcommittee.

On January 3, at the Hughes Aircraft corporate headquarters in California, GM unveiled its prototype electric car called the Impact. With acceleration from zero to 60 miles an hour in eight seconds and a governed top speed of 75 miles an hour, the Impact is the first electric car with performance comparable to today's contemporary gasoline-powered cars. Its full depth of discharge range is 125 miles. The Impact is equipped with on-board recharging equipment and can be almost completely recharged in two hours.

For competitive reasons, we have not announced the specifics of our program to produce the Impact, including where it will be built, when the car will be ready for sale, or how much it will cost.

The Impact is a unique electric vehicle in that it has been purpose-engineered from the ground up. Mechanical, electrical, and aerodynamic efficiencies have been optimized in the interest of extending the range of the vehicle.

It should be pointed out that many of the technologies developed for the electric car have spin-off applications to other vehicles. Examples are improved tires, aerodynamic shapes, and lightweight structures.

The Impact uses lead-acid recombinant battery technology to achieve a range of 125 miles. Approximately 38 percent of the Impact's 2,250-pound total vehicle weight is batteries. If a battery could be developed that were lighter—

Mr. TORRICELLI. Could you repeat that, Mr. Zwerner? I didn't catch that.

Mr. ZWERNER. Pardon?

Mr. TORRICELLI. I didn't catch what you said about the weight.

Mr. ZWERNER. The weight is 38 percent of the total vehicle weight, which is 2,250 pounds.

If a battery could be developed that were lighter yet provide sufficient energy to achieve range and performance comparable to a conventional automobile, the prospects for electric vehicles in the marketplace would be greatly enhanced. General Motors supports efforts to encourage more research on advanced battery technology for electric vehicles.

Batteries are relatively simple devices. A single battery cell consists of two electrodes and an electrolyte and generally are liquid but can also be a solid in a system such as a lithium or a sodium type. But there are many tough scientific and engineering prob-

lems that need resolution in each battery system. These include material compatibility, high-volume manufacturing, reliability, durability, safety in charging and recharging, deep-cycle life, and cost.

In developing the Impact, the battery is an essential piece of the final picture. Advanced battery research for electrical vehicles at GM research laboratories involves lead-acid batteries, aluminum batteries, lithium batteries, and nickel-containing batteries. The goal is to develop low-cost batteries with improved power and energy, and at the Delco Remy Division, the GM's Freedom lead-acid battery technology is being extended to deeper cycling applications, such as electric propulsion. This would result in lower maintenance costs for electric vehicles. GM's subsidiary, GM Hughes Electronics Corporation, is investigating sodium-sulfur batteries.

The primary difficulty of electric vehicles now remains the ability to meet the customer expectation for range between recharging. In addition, recharging a battery-powered car takes considerably longer than refilling the gas tank. Battery costs offer yet another challenge to the engineering community to lower life cycle cost of ownership.

By embodying practical yet state-of-the art solutions to electric car problems, GM engineers have demonstrated that the Impact can exceed previous performance limits by a wide margin. With its excellent acceleration, the Impact, in a dramatic display of performance, beat the Nissan 300ZX and a Mazda Miata in zero to 60-mile performance acceleration tests. This graphic demonstration proves that electric vehicles can cope with today's traffic patterns and the public's perception of what is an acceptable electric vehicle alternative. Impact also has one of the slipperiest drag coefficients ever recorded at the GM wind tunnel.

Technological advances and focused efforts by industry and Government sources may make electric vehicles viable in large urban markets. However, the battery-driven electric car is not likely to be fully competitive with a petroleum-fueled car unless fuel prices rise drastically or important battery breakthroughs are accomplished. H.R. 3852 recognizes that incentives may be needed to encourage the introduction of electric vehicles.

The Impact shows us the potential for electric vehicles in our future, but there is much more development to be done and more research is needed in battery technology. The Impact is tangible proof that General Motors is serious about our drive to remain the auto industry's technological leader and about our pledge to continue to care for our customers.

Thank you.

[The prepared statement of Mr. Zwerner follows:]

Statement of

General Motors Corporation

to the

Subcommittee on Transportation, Aviation, and Materials

House Committee on Science, Space, and Technology

Presented by

John S. Zwerner

September 25, 1990

Washington, D. C.

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lighter, yet provide sufficient energy to achieve range and performance comparable to a conventional automobile, the prospects for electric vehicles in the marketplace would be greatly enhanced.

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gas tank. Battery costs offer yet another challenge to the engineering community to lower the life cycle cost of ownership.

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The Impact shows us the potential for electric vehicles in our future, but there is much more development to be done on the car, and more research is needed in battery technology. The Impact is tangible proof that General Motors is serious about our drive to remain the auto industry's technology leader and about our pledge to continue to care for our customers.

Thank you.

Mr. TORRICELLI. Thank you, Mr. Zwerner.

Mr. Zwerner, is there a Federal stimulus in particular that you would ask this committee to consider as it deals with the Department of Energy's electric vehicle program in the future?

Mr. ZWERNER. I think the emphasis has to be placed on the dollars spent in the research and development of alternative battery technology. The lead-acid battery is the first step in a journey, or an evolution, of electric vehicles. You have to get started; somebody has to make the beginning step to put high-volume vehicles in the marketplace; GM is going to do that; but there is a substantial amount of ongoing research that has to be done in the alternative batteries.

Mr. TORRICELLI. So I take it you all agree that, dollar for dollar, what this committee does should be focused almost exclusively on the battery research.

Mr. ROBERT DAVIS. Yes.

Mr. TORRICELLI. That seems to be a common thread through all your testimony.

But now, in addition to that, in the regulatory environment, the tax environment, do you have any other specific ideas you think the committee should consider?

For example, I had raised earlier the idea that in fleet mileage standards we come up with a ratio where any company that sells these vehicles—I know how you feel generally about the fleet mileage standards anyway, but accepting them as a reality for the time being, that idea of multiplying the numbers of sales, recognizing these vehicles have zero, to—as an offset for other vehicles you may sell as a stimulus. Do any of those kinds of ideas have any appeal to you?

Mr. ROBERT DAVIS. Mr. Chairman, there already is, as part of the Chrysler Loan Guarantee Act, a formula, and the TEVan under that formula would qualify as 158-mile-per-gallon for CAFE averaging.

Mr. TORRICELLI. I didn't know that, and that is a part of the loan guarantee program?

Mr. ROBERT DAVIS. Yes, sir. Strange, but—

Mr. TORRICELLI. It is strange.

Why did none of the three major auto companies, in your opinions, bid on the 10,000 vehicles in California?

Mr. ZWERNER. Let me try and answer that. I think there's an awful lot of things going on in the arena of electric propulsion, lots of different programs of varying size, anywhere from one to two to 10,000, whatever, and it's a focusing issue: Where are you going to try and focus your resources to bring something meaningful to the marketplace in terms of volume application of electric vehicles? GM has chosen to focus its effort on the Impact vehicle and bring that to market.

Mr. TORRICELLI. It is just not worth the effort or the expense even to take a leadership position in that it is a beginning?

Mr. ZWERNER. We have ongoing programs, as I believe most all of the auto makers do, with EPRI and the utilities groups, looking at and trying to support. GM provides gliders for the G-Van activity. We are all, in part, involved in some of these programs, but at

some point you need to focus on something and put your efforts behind that.

Mr. TORRICELLI. Mr. Wallace, I think you had mentioned earlier there being a range, getting in a range of acceptable performance. Of course, that is both a price range and a distance range and a convenience range. I don't want to risk anyone giving proprietary information here, but speaking in general terms, when we talk about range, when we talk about price, what is the target that needs to be approached? And that is for anyone to answer, but please proceed, Mr. Wallace.

Mr. WALLACE. Well, if you think of the situation on the showroom floor, I think you can pretty much see the answer yourself. When these vehicles come out, they will be compared to existing internal combustion engine vehicles by our customers. Now that customer is going to be looking at an electric vehicle, and side by side is going to be an internal combustion engine vehicle that purports to do the same tasks. If the electric vehicle has limited range, what will make up for that in terms of its other performance characteristics in the customer's eyes? How much range can the customer accept?

Tentatively, we have said—I think all of us—that 100 miles of range is a bare minimum, but the truth of it is that if I offer a 100-mile-range vehicle, everything else being equal, my customers are all going to buy the internal combustion engine vehicle. There has got to be a positive reason.

Mr. TORRICELLI. Well, give me an idea of a range, which may not even be technically achievable today, where you think that resistance begins to break down.

Mr. WALLACE. Around 250 miles.

Mr. TORRICELLI. Does everybody agree with that generally.

Mr. ZWERNER. I'd say generally in the 200 to 250.

Mr. WALLACE. And even then, Mr. Chairman, there is the issue of refueling time. Even that vehicle could not be used on a cross-country trip.

Mr. TORRICELLI. No, though Mr. Zwerner, talking about the two-hour refueling time is better than I had heard previously; that is actually quite impressive.

Mr. ZWERNER. And that's dependent on whether you are using 220 volts.

Mr. TORRICELLI. Given the kind of vehicles that you are envisioning, like an Impact, are the batteries so numerous and so heavy that the kind of Swiss program that we saw of battery exchange in a utility program is not feasible?

Mr. ZWERNER. I think you would have to purpose engineer the vehicle to be able to exchange the batteries.

Mr. TORRICELLI. You would, but even so—I haven't seen the Impact; I hope to, but I haven't seen it—are the numbers too great to have a practical exchange program in a vehicle like the Impact?

Mr. ZWERNER. There are 32 individual batteries.

Mr. TORRICELLI. So the answer is yes. You couldn't go out for—you couldn't drive 200 miles and on the return trip exchange 32 batteries to come home.

Mr. ZWERNER. It depends on if you were to design the battery pack to be a single unit to be replaced or if you were trying to replace 32. Certainly, that would take too long.

Mr. TORRICELLI. Of course, you said 38 percent of the weight of the vehicle is batteries. You were talking about hundreds of pounds.

Mr. ZWERNER. Eight hundred and seventy pounds.

Mr. TORRICELLI. So, in fact, that kind of exchange program is not practical with the level of technology we are now talking about, at least in my opinion. I answered my own question.

Mr. ZWERNER. I think we are trying to move and trying to add some meat around this issue of what would bring people over to an electric car. They would typically not like to give up anything in moving from their current level of comfort with the internal combustion engine, and so you have to make it as practical a transformation as possible, and I think the Impact demonstrated performance levels that take the vehicle out of the perceived golf cart kind of mentality into something that can merge and work with traffic.

Mr. TORRICELLI. Is there a need for the public to have to accept some level of compromise on cubic inches within the automobile or general convenience, or for the Federal Government to accept a level of compromise on safety, or can the current expectations and standards generally be maintained, from your experience in designing Impact or from either of your other experiences?

Mr. ZWERNER. The Impact is designed to meet all of the safety standards, but the electric vehicle is very sensitive to mass. So if you have to accomplish some safety standard and add mass to the vehicle, that directly shows up in range of the vehicle.

Mr. TORRICELLI. It has a dramatic impact?

Mr. ZWERNER. It is almost, you know, 1 percent increase in mass will end up with a 1 percent decrease in range.

Mr. TORRICELLI. How serious is the problem of the numbers of these batteries we would generate based on current battery technology and the problems of recycling them, and not having an enormous waste disposal problem?

Mr. WALLACE. That depends on the battery technology that you are using.

Mr. TORRICELLI. Talking about where we now are with battery technology.

Mr. ZWERNER. Current lead-acid technology, our Delco Remy Division feels that it can be—

Mr. TORRICELLI. They can handle the recycling of this kind of technology.

Anybody else?

Mr. WALLACE. And the sodium sulphurs that we are looking at, Asea Brown Boveri is prepared to recycle all those batteries also.

Mr. TORRICELLI. How real is the risk that at some point in the nineties a foreign or foreign existing automobile company or a foreign small entrepreneurial company is going to reach a different judgment than you have reached and believe that there is a consumer market for a 100-mile small vehicle as a second, or third, or delivery vehicle, and come in and establish the credibility or seize the market? Is that a real threat in this decade?

Mr. WALLACE. The Fiat and Peugeot vehicles were mentioned as potential competitive threats. I think it is worth mentioning that those are extremely limited vehicles, somewhat old technology involved, and they are being sold in a market where the price of gasoline relative to the price of electricity is four times that of the United States.

Mr. TORRICELLI. Or was four times.

Mr. WALLACE. It may still be relative, I don't know, but certainly in a market in France and Italy, where that is much more favorable.

Mr. TORRICELLI. So you discount that threat in the nineties?

Mr. WALLACE. Those vehicles have top speeds of 40-some-odd miles an hour and ranges in that general area and not really very suitable.

In general, I think any manufacturer, whether he is an entrepreneurial, small one, or a foreign one, or anything, has to deal with the same basic issues of battery weight versus vehicle weight.

Mr. TORRICELLI. Someone just may come up with a different judgment on consumer reaction. They may have less of a technology but reach a different marketing analysis. And I am only asking you, recognizing that it is pure speculation, whether you think that is likely to happen.

Mr. Davis.

Mr. ROBERT DAVIS. I think there is a good test case right out there in the marketplace now. The G-Van has passed all the certification tests and is currently available for sale.

Mr. TORRICELLI. Good point.

Mr. ROBERT DAVIS. And if somebody wants one—now that doesn't have your 100-mile range, but it has a 60-mile range, and it sells for about $60,000. So customers can buy that, and I don't think they're being overwhelmed with orders. What we are talking about is something that gets you out—

Mr. TORRICELLI. At that price, it seems less than attractive.

Mr. WALLACE. We are not seeing—and I assure you that we look very carefully—anything, either in Japan or in Europe, to indicate that there is an effort different, qualitatively or quantitatively, than the effort we are mounting here.

Mr. TORRICELLI. Let me talk about the qualitative one for a minute. I was rather surprised to hear the Department of Energy's testimony that there was no American leadership, that indeed others may have shared the current level of technology. Is there another—this is sort of a classic softball, but is there anybody else in the world today who is capable of building a car like the Impact, Mr. Zwerner?

Mr. ZWERNER. Yes, I believe there are.

Mr. TORRICELLI. You believe there are.

Europe and Japan?

Mr. ZWERNER. Pardon?

Mr. TORRICELLI. Europe and Japan?

Mr. ZWERNER. Yes, I think what the Impact did was bring a lot of technologies together in a purpose-engineered car.

Mr. TORRICELLI. It, of itself, has no breakthrough; it's just that you designed it from the ground up, incorporating all of these technologies.

Mr. ZWERNER. There are quite a few patents that were generated in building this car, in inventing the car, but there are no major breakthrough technologies that would keep somebody else from not doing the same thing.

Mr. TORRICELLI. And should we expect in the next few years to see a variety of international Impacts?

Mr. ZWERNER. I think we have awakened the world to focus on electric vehicles, and I think it is critical and paramount that we being to press hard in the development of new battery technologies.

Mr. TORRICELLI. If the Impact level technology is to be the standard for a number of years, is there a price of oil that any of you have in mind that begins to dramatically change public acceptance of whatever inconveniences or problems that may have as an alternative to a gasoline-powered automobile? Any rule of thumb generally discussed in the industry?

Mr. ZWERNER. No, I'd say there's no rule of thumb that I know of.

Mr. TORRICELLI. Tell me generally, how would you evaluate, with the resources this committee has given the Department of Energy to date to work in battery research, in their management of the programs, the kind of progress they have made, how should we feel about the Department of Energy's management work to date?

Mr. ZWERNER. I think the overall Department of Energy philosophy is one of scoping down to get the fewer number of alternatives and put more dollars on an individual technology. I wholeheartedly support that kind of approach.

Mr. TORRICELLI. You agree with that.

Mr. ZWERNER. I think the number of dollars that are going to have to be expended to be competitive, leading edge, in the battery technology development has got to be substantially more than it is being looked at today.

Mr. TORRICELLI. The kind of infrastructure changes that we talked about with public utilities, whether it is marketing charging systems or highway recharging systems or battery exchange programs, are we significantly getting ahead of ourselves? It is an appropriate role for utilities? Should we be, at this point, pushing utilities to do that kind of creative thinking? Give me a general reaction.

Mr. ZWERNER. I think we should. We are potentially pushing the end of the distribution system, if we go all the way to the end consumer, to his house, plug in the car—you know—do the recharging there. This is at the very end of the distribution system, and so there has got to be a lot of thought put into load leveling, new equipment, those kinds of things, and I think it is not too early for the utilities to begin to strategize what the right approach is there.

Mr. WALLACE. I think also the concept of having the utility own the battery pack is one that has some potential, because then the consumer is basically faced with one fuel bill as opposed to two, trying to calculate the battery's loss of life.

Mr. TORRICELLI. I would think from a utility perspective it is extremely attractive that way.

You, of course, are all not simply American companies, you are international companies, and the market forces which may not yet make these vehicles attractive in the United States could be re-

markably different in other places, as you noted, the price of gasoline being several times in Europe what they are today. A vehicle like Impact, which you might find has market resistance here, where people may drive a distance where the 60-mile limit makes no sense, and where the price of the battery compared to the price of the gasoline makes no sense, might be remarkably different in Europe, where people drive far less distances and pay a lot more for gasoline. Is this evaluated in an international market situation separate from domestic market circumstances, or will you not take the leap until you see the domestic potential?

Mr. ZWERNER. I think your conclusion about the geographical compactness of Europe and some of those countries, and they are already experiencing cities that do not allow internal combustion engine vehicles to operate during certain times of the day, they are a prime area to be looked at as a market; they are environmentally very, very concerned; so I think electric vehicles are an international product.

Mr. TORRICELLI. Of course, I'm sure the danger—the fear of many of my colleagues would be that as we, perhaps properly, pursue the better vehicle, someone with a lesser product who enters the market establishes credibility, establishes experience and consumer acceptance, their lesser vehicle may become a standard while we pursue perfection, which I hope is not the case. This is something where American technology should allow us to capture a very important and emerging market.

This committee obviously, having jurisdiction over the Department of Energy and these general research projects, is going to take a continuing interest and evaluation of the technologies. This is not something we intend to do once and leave for a year. It will be a constant process of evaluation, because we have a number of Members here who are very interested in the general technology.

I hope as we go forward, if there are things you feel we should know, things we could do better, changes we could make, changes the Department of Energy could make, that you will remain in contact with us and the committee staff. Rarely will you find, particularly in your industry, Members who are more willing to work to advance what it is you are trying to achieve than you will find here with this product and this technology.

Thank you. I apologize for any inconvenience today in that it has been lengthy and we have been interrupted a number of times, but we are very pleased to have received your testimony. Thank you for your time.

[Whereupon, at 5:10 p.m., the subcommittee was adjourned.]

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